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Evaluation of Level of Milk Potential on Nutrient Balance in 2- and 4-Year-Old May-Calving Range Cows Grazing Sandhills Upland Range

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Summary with Implications

A modeling study evaluated the effects of milk production level on nutrient balance in May-calving cows grazing Sandhills upland range during the breeding season. Forage quality of upland range peaks in June and steadily declines in July until November. With timing of forage quality decline and increasing nutrient demands due to lactation, cows were in a negative energy balance in late June and early July prior to deficiency of metabolizable protein. Supplementation to meet energy deficiencies in June and July and MP deficiencies in July with distiller grains that is high ruminally undegradable protein and high fiber energy may be needed in May-calving cowherds. Selection for milk over 23 lb at peak lactation creates deficiencies early post-calving and increases the need for additional supplementation to correct the nutrient deficiency. In an effort to match cow type to environment in the Sandhills and optimize performance, producers should consider selecting against high milk potential.

Introduction

Selection for growth-oriented traits including milk production has been a focus in the beef industry in effort to maximize output. As milk production potential increases in beef cows, cow maintenance requirements during gestation and lactation increase. For instance, energy requirements for cows with a high milk production required 11% more energy to support an increased level of milk production compared to low milk cows. Matching cow type or genetic potential to the production environment is and will be more important as cost of production increases. The continual increase in selection for milk production has resulted in range beef cows that are under greater nutritional stress in critical physiological periods, such as early lactation, that may ultimately reduce reproduction. Due to increased nutrient demand of lactation, cows often experience extended periods of negative energy balance after calving, which can have a negative impact on reproductive performance. This particularly is an issue when breeding on declining forage quality during mid- to late-summer. Inadequate nutrient intake to meet production energy requirements can result in reduced reproductive performance. Therefore, the objectives of this study were to demonstrate nutrient balance of lactation in May-calving cows grazing Sandhills upland range with 18, 23, and 28 lb of milk potential at peak lactation.

Procedure

Using the NRC model (NRC, 1996), net energy for maintenance, rumen degradable protein (RDP), metabolizable protein (MP) balances were predicted for 2- and 4-yr-old May-calving cows grazing Sandhills upland range from late-July and August during the breeding season. The amount of additional supplemental dried distiller grains were utilized in the model to meet maintenance requirements for energy and protein. Native range diets for this model were collected using esophageally-fistulated cows at the University of Nebraska's Gudmundsen Sandhills Laboratory (*1997 Nebraska Beef Cattle Report*, pp. 3–5) and previously used to model March- and May-calving herds (*2019 Nebraska Beef Cattle Report*, pp. 21–23). Cows were modeled to have 18, 23, or 28 lb of milk potential at peak lactation as a mature cow. The NRC model predicted 2-yr-old cows with 18, 23, or 28 lb of milk potential to be producing 26% less milk at peak lactation than they would as a mature cow.

Assumptions for the model were:

1. Cow body weight = 875 and 1175 lb for 2- and 4-yr-old cow; respectively
2. Average calving date = May 9th and May 22nd for 2- and 4-yr-old cow; respectively
3. Body condition score = 5.0
4. Peak milk production = 18, 23, or 28 lb
5. Estimates of dry matter intake were based on NRC model estimations
6. Breeding season started on July 26th for May-calving herd.

Results

Matching nutrient availability of range with nutrient requirements of the cow has been recommended to efficiently utilize forage quality. In doing so, changing calving date has been utilized to match nutrient requirement of genetic potential for milk production with the greatest nutrient value of the forage. However, as forage quality of upland native range peaks in June and steadily declines in July until November, forage quality and nutrient intake may impact reproductive performance in summer calving herds. For instance, previous research has illustrated that pregnancy rates in mature cows from March or May-calving herds are similar (*2001 Nebraska Beef Cattle Report*, pp 8–9); however, pregnancy rates in May-calving heifers are decreased compared to March-calving heifers (*2017 Nebraska Beef Cattle Report*, pp 8–10). This may be partially due to an imbalance of milk production and environmental condition. Moving cows from a spring-calving herd to a summer-calving herd matches calving date with increased quality forage to reduce feed costs compared to spring calving herds (*2001 Nebraska Beef Cattle Report*, pp. 8–9). However, due to the increase in nutrient requirement at peak lactation (approximately 60 days postpartum) with the concurrence of the start of breeding season, supplemental inputs during the breeding season may need to increase in May-calving herds, especially in young range cows, to optimize or maintain adequate pregnancy rates.

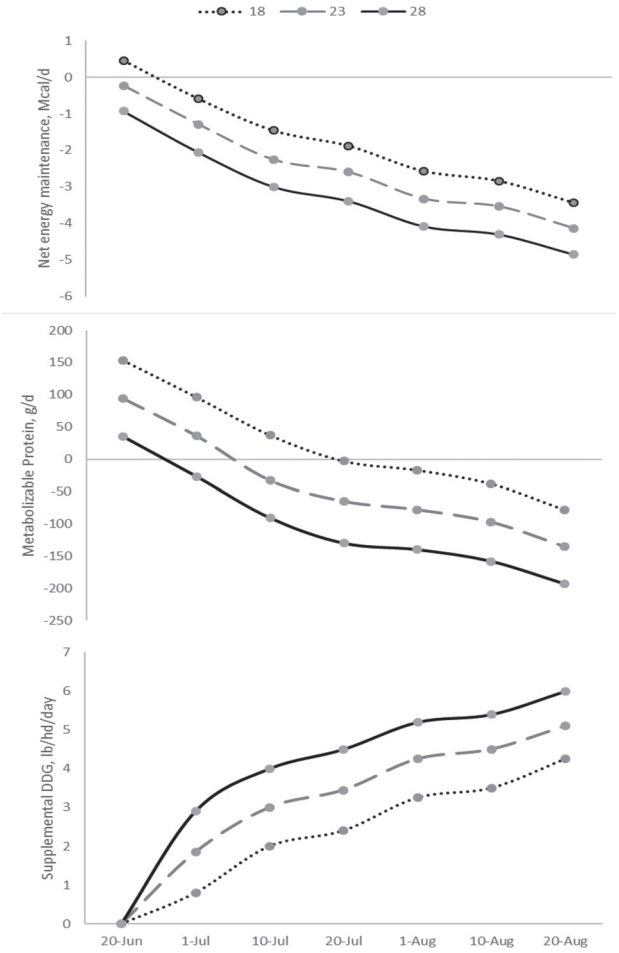

Figure 1. Evaluation of NEm balance (top graph), metabolizable protein balance (middle graph), and supplemental DDG needed to meet maintenance requirements (bottom graph) for May-calving 2-yr-old cow with milk production ranging from 18, 23, and 28 lb of milk at peak lactation while grazing Sandhills upland range.

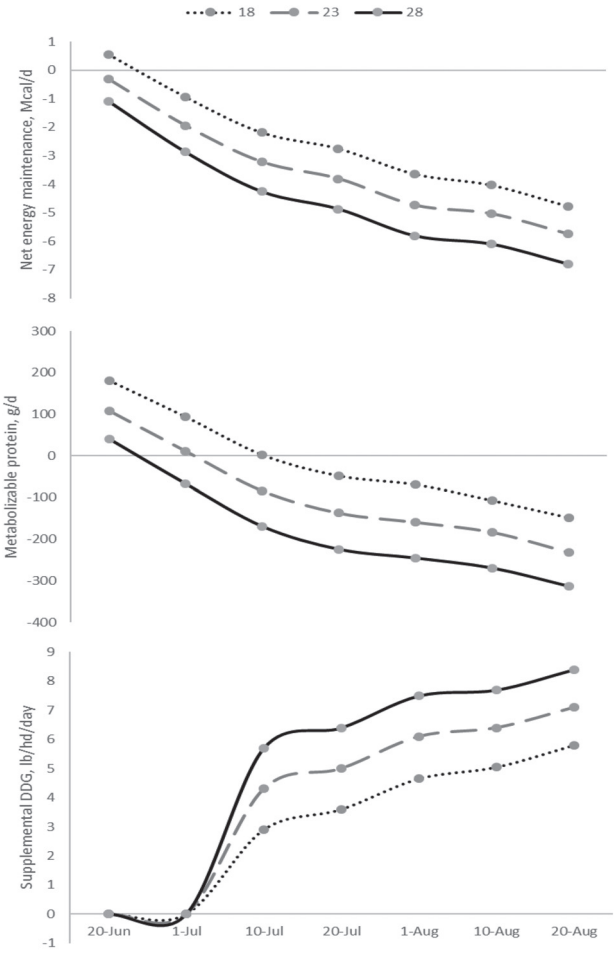

Figure 2. Evaluation of NEm balance (top graph), metabolizable protein balance (middle graph), and supplemental DDG needed to meet maintenance requirements (bottom graph) for May-calving 4-yr-old cow with milk production ranging from 18, 23, and 28 lb of milk at peak lactation while grazing Sandhills upland range.

In both age groups, NEm balance was in a deficit in late June ~ 30 d before the start of breeding and continued to be deficient through the breeding season. Even with low milk potential at 18 lb at peak, energy balance was deficient starting in first of July with increasing energy deficit as milk production increases. Without supplemental feeds, coming into the breeding season in a negative energy balance creates a scenario that cows have to have the ability to mobilize and utilize stored body fat and lean tissue. In contrast, MP balance was above requirements until early to mid-July depending on milking level. With increasing milk level from 18 to 28 lb, MP deficiency occurred early in July. The energy and MP deficiencies put more stress on younger, lactating cows, which will have a larger impact on reproductive performance. Young beef cows are calving for the first or second time, supporting calf growth, and require additional nutrients for growth to reach their mature BW. These factors contribute to increased nutrient demand, resulting in young beef cows having extended days to resumption of estrus after calving and lower pregnancy rates compared to mature cows. A driving factor of rebreed performance in young range cows is timing of resumption of estrus. Previous milk production and resumption of estrus have shown that postpartum interval increases 1.5 to 2.5 d/lb of milk produced in 2- and 3-yr-old range cows. Selecting beef cows with moderate milk potential may reduce the need for supplemental energy and protein and increase reproductive performance and longevity in the cowherd.

Similar to previous studies (*2019 Nebraska Beef Cattle Report*, pp. 21–23), RDP balance (graphs not shown) was in excess and was predicted to be from 71 to 167 g/d above requirements during the period of the study. In July when MP deficiency occurs, supplements high in RDP will likely not correct the MP and energy deficiencies and may be a less effective strategy to improve cow performance. Supplementation with a high RUP supplement with increased fiber energy content such as distillers grains may still be needed in young cows to meet the deficiency in MP and energy. The bottom graph in Figure 1 and 2 illustrate the

predicted amount of DDG needed to meet nutrient requirements in 2- and 4-yr-old cows. In 2-yr-old cows, this model predicts that DDG supplementation for energy and MP would need to start July 1 with amounts needed increasing as the breeding season progresses. In addition, as milk production level increases, supplementation needs would increase ~2 fold from an 18 to 28 lb peak milk potential cow. For 4-yr-old range cows, supplementation would start during the first week of July and increase in amounts needed through the breeding season. The 4-yr-old cows required more supplemental DDG to meet requirements due to their increased actual milk production. However, previous research has illustrated that pregnancy rates in mature cows from March or June-calving herd are similar (*2001 Nebraska Beef Cattle Report*, pp 8–9). This similar reproductive response in mature cows compared to the decline in young cows is partially due to increased nutrient requirements for young cows for growth. If pregnancy rates in mature cows are lower, cows may respond positively to distiller grain supplementation.

Conclusion

In forage-based beef systems, balancing the environment (forage quality and quantity) and cow requirements is the foundation for production efficiency. The need for livestock producers to match cow size and milk production potential to forage resources in order to optimize forage utilization and reproductive efficiency is critical. In May-calving herds, lactating cows were deficient in MP and NEm during the breeding season. With RDP requirements in surplus during the breeding season and as milk potential increases, there is a greater demand to supply supplementation that would meet the energy and MP deficit. To increase reproductive performance in a July breeding season with May calving, young range cows, supplementation may need to start approximately 4 weeks before the start of breeding.

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Effect of Age of Dam on Heifer Progeny Performance

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Summary with Implications

Cattle records were gathered and evaluated over a 12-yr period to investigate how cow age impacts heifer progeny growth and reproductive performance. Cow records from March and May calving herds, were categorized into young, moderate, and old groups based on their age at calving each year in the herd. Heifer calves born to young cows had lighter body weight at birth and adjusted 205-d BW than heifers from moderate and old cows. Heifer pre-breeding BW and pregnancy determination BW were not influenced by dam age. However, age of dam does impact the percentage of heifers to reach puberty prior to the start of breeding with no differences in percentage of heifers who calved within the first 21 d of calving in the subsequent calving season and pregnancy rates. Average number of calf crops from heifer progeny was different among all age of dam groups with young dams having more calves. Results from this study suggest older cows have a positive influence on growth and prebreeding puberty status in female progeny during heifer development. Heifer progeny from young dams, however, had increased calf crops and longevity within the cowherd.

Introduction

Selection and development of heifers can have long-term impacts on production and profitability. Developing females to replace cull cows is costly and one of the most expensive management decisions for cow-calf producers. Therefore, producers selecting replacement females place emphasis on both reproduction and growth value. However, younger females are thought to be genetically superior to older cow due to the rate of genetic progress. Age of dam is considerably varied within a herd and compounded with an array of effects on progeny performance, little is known regarding optimal dam age for selecting replacement females. Thus, it was hypothesized heifer progeny from moderate and mature cows would have increased growth during development, reproductive performance, and longevity in the cow herd. The objective of this study was to evaluate age of dam on female progeny performance and herd longevity.

Procedure

Cow and calf performance data were collected from 2005 through 2017 at the University of Nebraska, Gudmundsen Sandhills Laboratory (GSL) near Whitman, NE. Cow and calf performance data were obtained from both March and May calving herds at GSL to determine the impact of dam age on subsequent heifer progeny performance and longevity. Cows (n = 1,059) utilized in this study were Red Angus × Simmental and ranged from 2 to 11 yr of age. To determine the effect of age of dam on subsequent heifer progeny's growth development and reproductive efficiency, cows were also classified by age groups as young (2 to 3 yr old), moderate (4 to 6 yr old), and old (≥ 7 yr old). Heifer calves were weighed at birth and weaning each year. Weaning weights were adjusted for a 205-d weaning weight with no adjustments for sex of calf or age of dam.

Each year, all heifers were managed together within their respective breeding group. March-born heifers grazed meadow until early June then moved to upland native range, and May-born heifers continuously grazed upland native range. In each year, heifers were weighed at prebreeding and at pregnancy diagnosis. Prior to each breeding season, 2 blood samples were collected via coccygeal venipuncture 10 d apart to determine pubertal status (May for March-born heifers and early July for May-born heifers). Blood samples were placed on ice following collection and centrifuged at 2,500 × g for 20 min at 4°C. Following serum removal, plasma samples were stored at -20°C for pending progesterone analysis. Plasma progesterone concentration was determined via direct solid phase RIA (Coat-A-Count, Diagnostics Products Corp., Los Angeles, CA). Heifers with serum progesterone concentrations greater than 1.0 ng/mL at either collection were considered pubertal. Heifers were synchronized with a single $PGF_{2\alpha}$ (Lutalyse, Zoetis, Parsippany, NJ) injection 5 d after bull placement (1:20 bull to heifer ratio) for a 45-d breeding season. All heifers grazed Sandhills upland range through final pregnancy diagnosis. Pregnancy diagnosis was conducted via transrectal ultrasonography (ReproScan, Beaverton, OR) 40 d from bull removal. Calving distribution in 21-d intervals was calculated with the start of the calving season coinciding with the first day 2 or more heifers calved.

Data were analyzed using the GLIMMIX procedure of SAS (SAS Inst. Inc., Cary, NC). For reproduction and growth performance of heifer progeny, the linear model included fixed covariates of dam at the weaning (DAWW), and heifer progeny birthdate (BDATE), and fixed classification effects of age of the dam (young, moderate, and old; AGEDAM). Due to having data from 2 seasons of calving (March or May) nested within each year, year and season are not independent (YRSEAS), additional random effects were included for testing of the fixed effects. Error terms used for testing DAWW, BDATE, and AGEDAM were DAWW*YRSEAS, BDATE*YRSEAS, and AGEDAM*YRSEAS, respectively. Puberty diagnosis, pregnancy rate, and calving within first 21 d of the subsequent calving season were analyzed using a binomial distribution. All other response variables were considered normally distributed. Data are presented as LSMEANS and *P*-values ≤ 0.05 were considered significant and tendencies were considered at a $P > 0.05$ and $P \leq 0.10$.

Table 1. Effect of age of dam on growth performance of female progeny

	Dam Age[1]				
Items	Young	Moderate	Old	SE[2]	*P*-Value
Heifer BW, lb					
Birth	70[a]	75[b]	73[b]	0.9	< 0.01
205 d	438[a]	455[b]	453[b]	7	0.01
Prebreeding	612	625	621	9	0.21
Pregnancy diagnosis	820	820	809	9	0.17

[a,b]Means with different superscripts differ $P \leq 0.05$.

[1]Age of dam = age of dam at time of calving, Young (2 to 3 yr of age), Moderate (4 to 6 yr of age), Old (≥ 7 yr of age)

[2]SE is the SE of the difference between LSMeans.

Table 2. Effect of age of dam on reproductive performance of female progeny

	Dam Age[1]				
Items	Young	Moderate	Old	SE[2]	*P*-Value
Puberty, %	51.55[a]	69.64[b]	74.06[b]	9.7	< 0.01
Pregnancy, %	80.44	84.08	85.89	2.5	0.15
Calved in first 21 d, %	73.34	77.88	78.94	3.0	0.28
Calf Crop[3], n	3.1	2.8	2.2	0.7	< 0.01

[a,b]Means with different superscripts differ $P \leq 0.05$.

[1]Age of dam = age of dam at time of calving, Young (2 to 3 yr of age), Moderate (4 to 6 yr of age), Old (≥ 7 yr of age).

[2]SE is the SE of the LSMeans.

[3]Number of calf crops produced within age of dam groups.

Results

Heifer calves born to young cows had lighter ($P \leq 0.01$; Table 1) birth BW and 205-d BW than heifer calves born to moderate and old cows. Although pre-weaning BW differences occurred, heifer prebreeding and pregnancy determination BW were not different ($P \geq 0.17$) among dam age groups. Female progeny born to moderate and old cows had a greater ($P < 0.01$, Table 2) percentage reach puberty prior to breeding compared with heifers born to young cows. Age of dam did not influence ($P = 0.15$) heifer progeny pregnancy rates. This could be attributed to post-weaning growth, as no BW differences were observed among the groups suggesting heifer post-weaning intake and plane of nutrition impacted reproduction success. In the subsequent calving season, there were no differences ($P = 0.28$) among age groups for percentage of heifers who calved within first 21 d of calving. Average number of calf crops from progeny within dam age was different among all groups ($P < 0.01$), with heifer progeny from young and moderate dams having more calves than and old dams. These findings suggest as age of dam increases retention and productivity of female progeny tend to decrease.

Conclusion

Results from this study suggest age of dam will impact growth and reproductive performance of female progeny. Female progeny from moderate and older dams tended to have increased performance up to first calving. Female progeny from young dams, however, had increased calf crops and productivity compared with their older counterparts. Depending on production goals, age of dam may need to be considered for selecting replacement females with the goal of increased productivity and long-term profitability.

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Effect of GnRH Injection at -72 h in MGA-PG Estrus Synchronization Protocol

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Summary with Implications

Yearling beef heifers from 2 locations were synchronized with melengestrol acetate (MGA)-prostaglandin $F_{2\alpha}$ (PGF) fixed time AI (TAI) protocol. At PGF administration 72 h before AI, heifers were randomly assigned to receive either 0 or 5 μg gonadotropin-releasing hormone (GnRH). The administration of 5 μg GnRH at PGF did not increase estrus activity or improve TAI pregnancy rates at either location (Location 1, 56% (GnRH) vs. 57%; Location 2, 59% (GnRH) vs. 53%). Administering GnRH at PGF increased (74% vs. 63%) pregnancy rates for heifers inseminated during a follow-up heat detection period at one location. A low dose of GnRH administered 72 h prior to AI in a 14 d MGA-PGF synchronization protocol does not increase pregnancy rates or estrus expression in yearling, beef females bred with TAI when compared to the normal MGA-PGF synchronization protocol.

Introduction

Artificial insemination allows producers to utilize proven superior genetics with a larger group of females. When combined with estrus synchronization, a more uniform calf crop is born earlier in the calving season with greater weaning weights. Single service AI alone does not produce the same pregnancy success as a 45 to 60 d breeding season with bulls. The challenge is getting all females to synchronize and come into estrus before AI and ovulate shortly thereafter. Estrus synchronization protocols are constantly being analyzed and improved in hopes of increasing pregnancy success to AI.

The objective of this study was to determine if administrating 5 μg GnRH to young beef females 72 h prior to insemination in an MGA- PGF fixed-time AI (TAI) estrus synchronization protocol improved pregnancy success. The addition of this small dose of GnRH is to mimic a natural physiological pulse of luteinizing hormone and increase estradiol circulation, which is to increase estrus expression and potentially improve pregnancy success.

Procedure

Angus-based, commercial, yearling heifers (n = 1,518) from 2 locations in central Nebraska were randomly assigned to 1 of 2 treatments, 0 or 5 μg GnRH at PGF administration 72 h before insemination. Both operations utilized MGA-PGF TAI (0.5 mg MGA/hd per day for 14 d) estrus synchronization protocol with location 1 following up with heat detection and breeding (Figure 1).

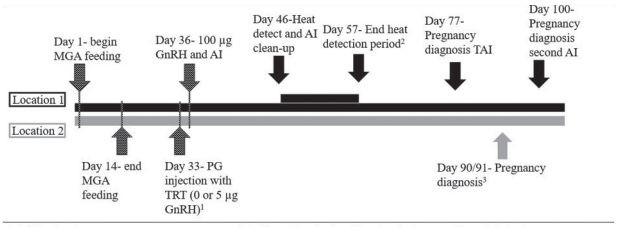
Heifers at the first location (n = 1,071; 843 ± 7 lb; Ainsworth, NE) received 25 mg of PGF i.m. (Lutalyse-Zoetis Animal Health, Parsippany, NJ) 72 h prior to AI. At the time of PGF administration, every third heifer was injected with 5 μg GnRH (Factrel, Zoetis Animal Health, Parsippany, NJ). The injection was administered i.m. with a Tuberculin syringe. At AI, all heifers received 100 μg of GnRH i.m. After initial TAI, all heifers were observed 10 to 21 d post-breeding for estrus behavior and any heifers showing estrus were inseminated 12 h later. Forty-five days after TAI, pregnancy diagnosis was performed on heifers not expressing estrus after TAI. Heifers inseminated a second time were diagnosed for pregnancy approximately 45 d after the follow-up estrus detection period. Bulls were used as clean-up, but not until after AI pregnancy diagnoses; therefore, only AI breeding results are reported.

At the second location (n = 447; 799 ± 15 lb; Sutherland, NE) 72 h prior to AI, every heifer received PGF and estrus detection patches (Estrotect; Rockway Inc., Spring Valley, WI) were applied. The GnRH treatment was administered to every other heifer through the chute. At AI, all heifers received 100 μg of GnRH i.m. Patch scores (1: 0% rub-off coating removed, 2: < 50% activated, 3: ≥ 50% activated, 4: patch missing) were recorded and removed at breeding. At location 2 no clean-up bulls were used, heifers only breeding exposure was TAI. Pregnancy diagnosis was performed via rectal palpation approximately 55 days post AI.

Results

Treatment with 5 μg GnRH 72 h prior to AI did not ($P < 0.20$) improve pregnancy rates at either location (Location 1, TAI, 56% (GnRH) vs. 57%; Location 2, TAI, 59% (GnRH) vs. 53%). There was no effect of location on treatment nor an interaction between treatment and location ($P = 0.23$). At the first location, 5 μg GnRH did improve ($P = 0.03$) pregnancy rates for those inseminated during the follow-up heat check period (74% vs. 63%, 5 μg GnRH vs. 0 μg GnRH, respectively). There was no ($P = 0.20$) increase in heifers not conceiving after the initial TAI that expressed estrus and were rebred for the treatment (68%) than control (62%) at location 1. The GnRH treatment tended ($P = 0.11$) to improve final pregnancy rates at location 1 over control heifers (78% vs. 74%, respectively).

At location 2, 5 μg GnRH did not ($P = 0.64$) affect patch score as pregnancy rates were similar between 5 μg and 0 μg GnRH groups within each patch score category (1- 29% vs. 26%; 2- 40% vs. 33%; 3- 71% vs. 66%; 4- 57% vs. 56% 5 μg GnRH vs. control, respectively). There was an ($P < 0.01$) association between observed patches activated (high activation patch score) on pregnancy rate in heifers, which was to be expected as estrus expression (patch activated) is associated with pregnancy success. There was a ($P = 0.01$) pen effect on patch score, which indicates a synchrony affect within each pen; however, pregnancy rates were similar ($P = 0.96$) among pens.



[1]Administration of 5 µg GnRH as treatment or 0 µg as control administered i.m. via tuberculin syringe simultaneous with PG administration
[2]Location 1 utilized a follow-up estrus detection and AI period from 10 to 21 d following initial TAI
[3]Pregnancy diagnosis was conducted via rectal palpation at both locations

Figure 1. Timeline of a melengestrol acetate-prostaglandin (MGA-PG) synchronization protocol at 2 separate locations with treatment of 5 µg gonadotropin-releasing hormone (GnRH) 72 h prior to fixed-time AI (TAI).

Conclusion

In summary, a low dose (5 µg) of GnRH administered in conjunction with PG 72 h prior to AI in a 14 d MGA-PG synchronization protocol does not increase pregnancy rates or estrus expression in yearling beef females bred with TAI, however may influence return to estrus in those that don't conceive to the initial AI.

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Efficacy of a Second Injection of Prostaglandin $F_{2\alpha}$ in Yearling Beef Heifers Following Previous Estrus Synchronization

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Summary with Implications

Angus-based, yearling beef heifers were utilized to determine the effects of administering a second prostaglandin $F_{2\alpha}$ (PGF; Lutalyse, Zoetis Animal Health, Parsippany, NJ) injection to heifers who did not previously respond to estrus synchronization. All heifers were exposed to a melengestrol-acetate (MGA)-PGF protocol. Following PGF injection, heifers were observed for estrus (estrus detection patches rubbed) for 3 d and inseminated. Heifers who did not show signs of estrus were placed with fertile bulls. After 3 d with bulls, heifers with greater than 50% of the rub-off coating removed from estrus detection aids were considered to have been bred. One-half of the heifers not showing estrus received a second PGF injection; the other half were the controls and received no further treatment. Heifers remained with bulls for 4 d. Percentage expressing estrus was greater for heifers receiving a second PGF injection. However, pregnancy rate was similar between treatments.

Introduction

Estrus synchronization can shorten the subsequent calving season by increasing the females coming into estrus to begin breeding season and subsequently increase the number of calves in the first 21 d of calving. This will produce a more uniform calf crop with greater weaning weights. Prostaglandin $F_{2\alpha}$ (PGF) induces estrus and is used to synchronize cattle for breeding either by natural service or artificial insemination (*2009 Nebraska Beef Cattle Report*, pp. 9–10). Females that don't exhibit estrus after the first round of AI would benefit from a quick return to estrus to become pregnant.

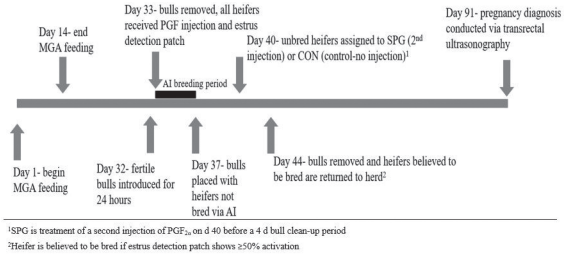

Figure 1. Timeline of 14 d MGA-PG protocol with treatment of PGF on d 40 for yearling heifers.

A second injection of PGF 7 days after the initial dose could make that a possibility.

Procedure

The objective of this study was to determine the effectiveness of a second injection of prostaglandin $F_{2\alpha}$ to young beef females failing to display estrus following an initial melengestrol-acetate (MGA)-PGF estrus synchronization protocol.

Angus-based, yearling beef heifers (n = 1,858, 709 lb, Ashby, NE) were exposed to a melengestrol-acetate (MGA)-PGF estrus synchronization protocol. Heifers were fed 0.5 mg/d MGA for 14 days. On day 32, fertile bulls were placed with heifers for 24 hours (Figure 1). On day 33, bulls were removed, and all heifers received an injection of PGF and an estrus detection patch (Estrotect; Rockway Inc., Spring Valley, WI) was applied. Following PGF injection, heifers were observed for estrus for 3 days and inseminated 12 h after detection of estrus. Heifers were considered in estrus when greater than 50% of the rub-off coating was removed from the patch. Heifers who did not show signs of estrus (day 37, n = 331) were placed in a separate pasture with fertile bulls at a 1:33 bull to heifer ratio. After 3 days with bulls, heifers (n = 151) with patches activated over 50% were considered to have been bred and were removed and placed with the previously bred heifers. The remaining heifers, who did not show estrus (day 40), were randomly assigned to receive either a second PGF injection of equal dosage to the initial injection (n = 90, SPG) or no injection (n = 90, CON) and remained with bulls for 4 days. Following bull removal, SPG and CON heifers considered in estrus and assumed bred, (based upon activated patches) returned to the herd of AI and bull-bred heifers. Pregnancy diagnosis was conducted 47 days later via transrectal ultrasonography.

Results

Percentage of heifers expressing estrus was greater ($P < 0.01$) for SPG treatment (60% vs. 23% ± 13%, SPG [n = 53] vs. CON [n = 21]). Of the heifers expressing estrus in both treatments, pregnancy rate was similar ($P = 0.38$) between treatments (34% vs. 52% ± 11%, SPG [n = 18] vs. CON [n = 11]). The differences observed in estrus expression, yet no difference in pregnancy rates may be due in part to an insufficient number of females for detecting statistical differences. This was difficult to control since only females not responsive to the initial PGF injection could be included in this experiment.

Conclusion

In summary, a second PGF injection to yearling beef heifers that did not respond to an MGA-PGF protocol did increase the number of females that came into estrus, but did not improve pregnancy rates.

Overall, the number of pregnant females was increased as a result of increased estrus expression from a second injection of PGF compared to the control. This may be a viable method to increase the number of pregnancies and shorten the breeding season with a follow-up breeding without extending out 45–60 d in a typical bull breeding season.

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Evaluation of Commercial Genomic Tests for Maternal Traits in Crossbred Beef Cattle

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Summary with Implications

DNA samples were collected from beef heifers born at the Gudmundsen Sandhills Laboratory and analyzed with a genomic test. Phenotypic data from these females were compiled and used in a regression analysis to evaluate the utility of these genomic scores as predictors for phenotypic outcomes. The genomic score for birth body weight (BW) was significantly associated with animal birth BW. The genomic score for heifer pregnancy was not a statistically significant predictor of actual pregnancy. Neither dam age or the genomic score for stayability were significant predictors of actual reproductive longevity.

Introduction

Raising a replacement female can be a significant cost for cow-calf producers. Replacement females require inputs and management, which can be seen as an investment if that female remains in the herd producing a calf year after year until she has paid for those investments and more. Reproductive failure can result from many factors, but regardless, many producers will disqualify a female from remaining in the herd after just one failure to produce a calf. If this happens early in the female's life, then significant investment value is lost. Determining which females to retain as replacements can challenge many producers. Knowing pedigrees may increase confidence in the decision process, but newer technology available in the field of genomic testing may allow producers to make a more informed decision about keeping heifers with a higher probability of staying in the herd longer. Genomic predictors for longevity or stayability may help producers identify and select these females earlier and thereby reduce inputs into unwanted, inferior females.

The objective of this study was to evaluate the predictive ability of a commercial DNA test designed to predict genetic merit of crossbred females for stayability and other traits.

Procedure

Phenotypic data were collected from heifer calves born at the Gudmundsen Sandhills Laboratory (GSL), Whitman, from 2009 to 2012. In 2009, all calves were born in a March calving season and a May calving herd was initiated. In 2010 and 2011, hair samples were taken from both March and May calves. In 2012, hair samples were only taken from the March calving herd. Samples were collected as hair pulled from the tail with follicles and placed in a DNA hair sample card. This occurred at birth of each calf as birth body weight (BW) was measured and recorded.

After weaning, heifer calves were developed until first breeding at approximately 15 months of age. Each female was kept within the calving system (March or May) it was born in. All female calves were retained on the ranch and only removed for reproductive failure. Records were kept on all females and calving information taken each year for 5 subsequent years to determine their longevity in the herd. If a female never became pregnant as a yearling then it received a 0 for heifer pregnancy, and subsequently received a 0 from that point forward as it was removed from the herd. Stayability was calculated as the number of calves produced in a 5-year period for a maximum of 5 calves. Any calving data past 5 years was not included in this study.

DNA samples from 414 crossbred, female, beef calves were analyzed with the Igenity Gold panel (Neogen GeneSeek Operations, Lincoln, NE; Neogen Corporation, Lansing, MI). This panel uses gene markers to report the genomic value for 13 traits; 7 maternal traits: birth weight, calving ease direct, calving ease maternal, docility, heifer pregnancy, milk, and stayability; 2 performance traits: average daily gain and residual feed intake; and 4 carcass traits: tenderness, USDA marbling score, ribeye area, and fat thickness. Upon analyzing the DNA samples each female was assigned a score between 1 and 10 (10 being the best) for each of the 13 traits.

The heifer was the experimental unit in this design. The GLIMMIX procedure of SAS Software (SAS Institute, Inc., Cary, N.C.) was used to perform the regression analysis to evaluate the efficacy of the genomic test scores as predictors of the observed phenotypic traits. All models included calving season, age of dam, and birth year as independent variables along with the genomic scores corresponding to the dependent variable for that model. A P-value ≤ 0.05 was considered significant. A P-value > 0.05, but ≤ 0.10 would be considered a tendency.

The regression analysis was performed using 4 phenotypic traits as dependent variables: birth BW, weaning BW, heifer pregnancy, and stayability (total pregnancies out of a possible 5 years).

Results

The genomic score for birth BW was significant in explaining variation in the heifer's own birth BW ($P < 0.01$). Within the same model, dam age and birth year affected ($P \leq 0.01$) birth BW. Birth BW tended ($P = 0.09$) to differ between calving season with calves born slightly heavier (76 lb vs. 74 lb; May vs. March respectively) in the May calving season. Weaning BW was broken into 4 separate models to analyze 3 different genomic scores, one for each genomic score and one with all genomic scores together (combined). The genomic predictor scores used with weaning BW regression were milk score, calving-ease direct, and calving-ease maternal. Dam age

Table 1 Average of phenotypic traits of heifer calves born in each production year in two different calving seasons[1]

	n	Birth WT[2]	Wean WT[3]	Total Preg[4]	Heifer PG[5]
March 2009	61	75.7	465.1	2.2	0.64
March 2010	68	73.2	465.9	2.8	0.74
May 2010	58	77.2	411.8	1.6	0.58
March 2011	67	75.3	487.5	2.5	0.78
May 2011	66	74.7	433.7	1.7	0.65
March 2012	94	70.0	437.3	1.7	0.78
All March	290	73.6	464.0	2.3	0.74
All May	124	75.9	422.8	1.7	0.62

[1]Location managed two separate calving herds; March and May

[2]Birth body weight (BW) average of females in the contemporary group in lb

[3]Weaning BW average of females in the contemporary group in lb

[4]Average of number of pregnancies per female out of possible 5 years

[5]Average number of females (as percentage) successfully pregnant at first opportunity (yearling heifer)

and calving season had a strong impact ($P < 0.01$) on weaning BW with March-born calves heavier at weaning (464 lb vs. 423 lb; March vs. May, respectively; March calves weaned 8 d older than May calves, 224 d old vs. 216 d old) for all 4 models analyzed. Birth year impacted ($P < 0.05$) all 4 models. The combined model containing all 3 genomic predictor scores for weaning BW demonstrated calving-ease direct as a valid ($P < 0.01$) predictor for weaning BW and milk score tending ($P = 0.06$) to predict weaning BW. Calving-ease maternal was not ($P = 0.35$) a valid predictor for weaning BW within this model; however, when put in the model with calving season, dam age, and birth year it was a valid ($P = 0.01$) predictor of weaning BW. Calving-ease direct was a predictor ($P < 0.01$) within the model of its own, and the genomic score for milk was not ($P = 0.27$) a predictor of weaning BW when in a model on its own. It is important to note that the weaning BW used was the female's own weaning BW, not the weaning BW of her offspring. This needs to be recognized when interpreting the data.

The model results for heifer pregnancy showed dam age ($P = 0.31$) and birth year ($P = 0.11$) having slight effect while calving seasons showed difference ($P = 0.01$) in heifer pregnancy with averages of 74% for March and 62% for May born heifers (Table 1). The genomic score for heifer pregnancy was a non-significant ($P = 0.75$) predictor for phenotypic heifer pregnancy. The stayability model showed birth year ($P < 0.01$) and calving season ($P < 0.01$) influencing the longevity of a female and their ability to stay in the herd with March-born heifers averaging 2.3 calves vs. 1.7 for May-born heifers over a 5-year period. Dam age had little effect ($P = 0.16$) on stayability and the genomic score for stayability was not significant ($P = 0.88$) for the longevity of a female.

Conclusion

In summary, the genomic scores for birth BW and calving-ease direct are significant predictors for birth BW and weaning BW respectively. The genomic scores of heifer pregnancy and stayability were not significant predictors for actual heifer pregnancy and female longevity/stayability in this population.

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Combined Analysis on the Effects of Late Gestation Supplementation in a Spring Calving Beef Herd

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Summary with Implications

Data were compiled from 4 independent studies conducted over 13 years in the Nebraska Sandhills. This combined analysis evaluated the effects of late gestation supplementation on cow and calf productivity in a spring calving herd. Cows wintered on dormant range, sub-irrigated meadow or corn residue. Late gestation supplementation improved pregnancy rates regardless of supplement amount or over winter treatment. Supplement did not affect cow body weight and condition score. Calves born to cows fed supplement had greater weaning weights regardless of when they were weaned.

Introduction

Grazing dormant pastures in the Nebraska Sandhills reduces production costs by feeding less harvested feed. Supplementing the cow during mid to late gestation can help supply nutrients to meet the higher metabolic demands of the dam. Research has determined ruminally degradable protein (RDP) is necessary to maintain BCS of gestating beef cows when extending the grazing season on dormant forage. Feeding supplement to cows grazing winter range during the last trimester of gestation can increase calf BW at weaning (*2006 Nebraska Beef Cattle Report*, pp. 7–9). Even with increased progeny performance, there has been lack of evidence that late gestation supplementation benefits any cow production traits, including reproduction (*2018 Nebraska Beef Cattle Report*, pp. 18–20). It is possible more data points or analyzing multiple studies of similar treatments may show different results. The objective of this study was to determine if a combined analysis would demonstrate effects from supplementation on cow production traits, reproduction, and calf production traits.

Table 1. Effects of late gestation supplementation[1] on cow productivity

	Supplement				
Item	NS	SUP1	SUP2	SE[2]	*P*-Value
Cow BW, lb					
Initial	1,089	1,100	1,082	12.42	0.18
Weaning	1,093	1,102	1,091	8.60	0.32
BW change	-1.58	-1.78	-3.93	7.94	0.67
Cow BCS[3]					
Initial	5	5	5	0.08	0.23
Weaning	5	5	5	0.05	0.75
BCS change	-0.09	-0.10	-0.12	0.07	0.75
Calving date[4], d	82	83	81	1.85	0.26
Calved in first 21 d[5], %	84	86	85	0.05	0.53
Pregnancy rate[6], %	90[a]	94[b]	93[b]	0.02	0.01

[1]Supplement: NS:0 lb/(cow • d) Dec 1 to Mar 1;SUP1: 1 lb DM/(cow • d) Dec 1 to Mar 1; 1 lb DM/(cow • d) Jan 15 to Mar 1; SUP2 lb DM/(cow • d) Jan 15 to Mar 1.

[2]Standard error of the least squares mean.

[3]Scale of 1 (emaciated) to 9 (extremely obese).

[4]Day of year calving occurred where January 1 = d 1.

[5]Cows calving within 21 d calculated by finding difference between birth date and breeding date and subtracting from 285.

[6]Pregnancy rate calculated by dividing the number of cows determined pregnant by the number of cows at the beginning of the production year.

[abc]Within a row, means lacking a common superscript letter differ ($P < 0.05$).

Procedure

Studies were conducted over a 13 year period at the Gudmundsen Sandhills Laboratory, Whitman, NE. Data were compiled from 4 independent studies that spanned from 2001 to 2016 (*2018 Nebraska Beef Cattle Report*, pp. 18–20; *2012 Nebraska Beef Cattle Report*, pp. 15–17; *2011 Nebraska Beef Cattle Report*, pp. 5–7, *2009 Nebraska Beef Cattle Report*, pp. 5–8; *2006 Nebraska Beef Cattle Report*, pp. 7–9; *2006 Nebraska Beef Cattle Report*, pp.10–12). All studies had similar designs based on the consideration of late gestation supplementation and weaning periods.

Among all studies, 712 crossbreed (¾ Red Angus, ¼ Simmental), March-calving multiparous cows (479 ± 57 kg) were assigned to different overwinter treatments and weaning periods the first year. Cows were wintered on dormant range, sub-irrigated meadow, or corn residue. The 3 weaning treatments between all the involved studies were: 1) Nov, 2) Aug 18 vs Nov 7, or 3) early Oct vs early Dec. The original goal for these different weaning periods was to see how these dates affected the dam and their progeny. Three amounts of supplementation (32% CP, 89% TDN) were used: NS (0 lb (DM)/ (cow per day)), SUP1 (1 lb DM/ (cow per day)) and SUP2 (2 lb DM/ (cow per day)).

Cow BW (body weight) and BCS (body condition score) was measured at the beginning and end of the supplementation period, prebreeding and weaning. The average amount of days for supplementation was 90 or 45 days depending on the treatment. Calf BW and BCS were measured at prebreeding and weaning. Within all studies, cows were

Table 2. Effects of late gestation supplementation[1] on steer progeny productivity

	Supplement				
Item	NS	SUP1	SUP2	SE[4]	*P*-Value
Birth BW, lb	77[a]	79[b]	79[b]	1.2	0.02
Wean BW, lb	494[a]	505[b]	514[b]	6.28	< 0.01
Calf ADG, lb/d					
Birth to Wean	2.16[a]	2.23[b]	2.27[b]	0.04	< 0.01
Post weaning performance					
Live Weight	1,310	1,303	1,307	5.21	0.71
HCW, lb	825	820	825	5.21	0.71
12th rib fat, in	0.54	0.53	0.52	0.07	0.58
Marbling[2]	467	487	479	11.78	0.01
LM, in[2]	14	14	14	0.00	0.81
USDA yield grade	2.92	2.87	2.89	0.09	0.76

[1]Supplement: NS:0 lb/(cow • d) Dec 1 to Mar 1;SUP1: 1 lb DM/(cow • d) Dec 1 to Mar 1; 1 lb DM/(cow • d) Jan 15 to Mar 1; SUP2 lb DM/(cow • d) Jan 15 to Mar 1.

[2]Marbling: Small00 = 400, Small50 = 450, Modest00 = 500.

[abc]Within a row, means lacking a common superscript letter differ ($P < 0.05$).

Table 3. Effects of late gestation supplementation[1] on heifer progeny productivity

	Supplement				
Item	NS	SUP1	SUP2	SEM[2]	P-Value
Birth BW, lb	77	77	75	0.00	0.27
Wean BW, lb	485[a]	498[b]	492[b]	6.69	0.07
Calf ADG, lb/d					
Birth to Wean	2.16[a]	2.23[b]	2.27[b]	0.04	< 0.01
Post Weaning Performance					
Puberty Status[3], %	65	64	68	0.65	0.89
Prebreeding BW, lb	741	750	717	26	0.39
Prebreeding BCS[4]	5	5	5	0.10	0.80
Pregnancy diagnosis BW, lb	827	847	847	13.38	0.09
Pregnancy diagnosis BCS	6	6	6	0.04	0.80
Pregnant[5], %	90	89	91	0.67	0.94
Calved in first 21 d[6], %	70	69	79	0.48	0.46
1st calf wean BW, lb	441	434	445	8.55	0.60

[1]Supplement: NS:0 lb/(cow • d) Dec 1 to Mar 1;SUP1: 1 lb DM/(cow • d) Dec 1 to Mar 1; 1 lb DM/(cow • d) Jan 15 to Mar 1; SUP2 lb DM/(cow • d) Jan 15 to Mar 1.

[2]Standard error of the least squares mean.

[3]Puberty Status: Considered pubertal if blood plasma progesterone concentration > 1ng/mL.

[4]Scale of 1 (emaciated) to 9 (extremely obese).

[5]Pregnancy rate calculated by dividing the number of cows determined pregnant by the number of cows at the beginning of the production year.

[6]Heifers calving within 21 d calculated by finding difference between birth date and breeding date and subtracting from 285.

[abc]Within a row, means lacking a common superscript letter differ ($P < 0.05$).

managed as a single group post treatment period.

Within all studies, steer calves remained in drylot and were offered *ad libitum* hay for 2 weeks post weaning before being shipped 104 miles to a feedlot at the West Central Research and Extension Center, North Platte. Steers received a Synovex Choice (100 mg trenbolone acetate [TBA] and 14 mg estradiol benzoate [EB]) at the beginning of the feeding period. Steers were re-implanted with Synovex Plus (200 mg TBA and 24 mg EB) 105 d later (110 d prior to harvest). Steers were weighed at feedlot entry and at reimplant. Steers were slaughtered in mid-June (Tyson Fresh Meats, Lexington, NE). Carcass data was collected 24 hours following slaughter and final BW was calculated from HCW (Hot Carcass Weight) based on an average dressing percentage of 63%. Carcass data included HCW, yield grade, LM area, marbling, and 12th rib fat. Heifer management will be listed within each specific study that was referenced since the treatments varied between each individual study.

Cows assigned to the same winter supplement treatment and weaning period within winter pasture served as the experimental unit. Replicated treatment means within year were used for analyses of cow and calf response variables and carcass evaluation. In other words there was more than one group of each treatment. Model fixed effects included winter supplement treatment, weaning period, and all interactions. Year and residual error were included in the model as random effects. Effects of treatment were considered significant when $P < 0.05$.

Results

Within any amount, supplementation did not affect cow BW or BCS ($P = 0.18$). Contrary to the results of each study that comprises the analysis, this analysis demonstrated any amount of protein supplementation during late gestation positively affected pregnancy rates ($P = 0.01$). Each study utilized in this analysis saw no benefit of supplementation to cows during the third trimester of gestation on pregnancy rates. However in the combined analysis there was no difference between SUP1 and SUP2. Even with the impact on pregnancy rates in this analysis, protein supplementation did not affect calving date or the percentage of the herd calving within the first 21 days ($P = 0.26$).

Within this analysis, protein supplementation provided to the dam affected steer progeny birth ($P = 0.02$) and weaning BW ($P < 0.01$). Once progeny were born, steer calves had a higher ADG from birth to weaning when their dams were fed any level of protein supplementation ($P < 0.01$). The NS group had an overall ADG of 2.16 lb/d

compared with SUP1 of 2.23 and SUP2 of 2.27 lb/d.

The NS steers had a marbling score of 467 while SUP1 and SUP2 groups had a score of 487 and 479, respectively. Live BW for NS groups was 1,310 lb while SUP1 and SUP2 progeny weighed 1,303 lb and 1,307 lb ($P = 0.71$). Supplementation level did not impact ($P \geq 0.58$) live weight, HCW, 12th rib fat, LM, or USDA yield grade.

Focusing on the supplementation effects on heifer progeny birth and weaning BW this analysis demonstrated no effect on birth BW ($P = 0.27$). At weaning supplementation tended to affect BW ($P = 0.07$) of heifer progeny with NS averaging 485 lb and SUP1 and SUP2 averaging 498 lb and 492 lb per calf. These results suggest supplementation significantly affecting ADG of each group ($P < 0.01$). This analysis showed neither supplementation amount impacted puberty status ($P = 0.89$). Prebreeding BW and BCS were not affected by any amount of protein supplement to dam throughout this analysis ($P = 0.39$). These same results held true when considering BCS at pregnancy diagnosis ($P = 0.80$). Supplementation tended to affect BW at pregnancy diagnosis ($P = 0.09$) with NS having an average BW of 827 lb while SUP1 and SUP2 had an average BW of 847 lb for both groups. Pregnancy rate was not affected by supplementation ($P = 0.94$). Heifers from SUP1 and SUP2 dams had a similar percentage of calves born in the first 21 days of calving. This also held true in the weaning BW of the calves born to the heifer progeny ($P = 0.60$). Overall, this analysis demonstrated dam supplementation affects certain stages of heifer BW, but did not affect heifer reproduction measures.

In conclusion, the above results demonstrate that combining multiple data sets in similar environments may show us more accurate results when discussing supplementation and other treatments. Producers can start to see more applicable results with these higher numbers to evaluate.

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Comparing March and May Calving Systems in the Nebraska Sandhills

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Summary with Implications

Three production years for March and May calving, Red Angus-based cows and their offspring from the Gudmundsen Sandhills Laboratory (GSL), Whitman, NE, were evaluated. Steer progeny were evaluated through harvest and carcass data collected. Calf birth body weight (BW) and breeding BW were greater for May calves vs. March; however, adjusted weaning BW was greater for March calves. Pregnancy rates, weaning rates, calving interval, calving difficulty, and calf vigor were similar between calving systems. Udder score was greater for March cows. Compared with March calf-fed steers, May calf-fed steers had greater hot carcass weight (HCW), longissimus muscle area (LMA), marbling, and backfat. May yearlings had greater HCW, LMA, marbling, and backfat compared with March calf-feds. In the Sandhills, a May calving system can increase production while reducing total herd inputs when compared to a March calving system.

Introduction

Selecting a calving season can be one of the most influential factors for a successful beef production system. Weather, available labor and feed resources, market potential for calves and open cows, and breeding season impact the profitability of a calving season. In addition, location and producer goals will affect the decision about when to calve. When comparing March and June calving in the Nebraska Sandhills, a June calving system reduced labor and the amount of hay fed, but increased protein supplement needed for June cows (2001 Nebraska Beef Cattle Report, pp. 8–9).

Table 1. Comparison of calf performance between March and May calving systems

					P-value	
	March	SEM	May	SEM	System[1]	Cow Age[2]
n						
Birth wt, lb	77.34	0.46	78.06	0.64	0.02	0.01
Breeding wt, lb	173.0	1.56	213.83	1.97	0.01	0.01
Weaning wt, lb	533.62	2.89	441.43	3.62	0.01	0.01
Adj weaning wt[3], lb	499.18	2.45	426.33	4.44	0.01	0.01
Calving difficulty[4]	1.04	0.01	1.00	0.01	0.05	0.27
Calf vigor[5]	1.04	0.01	1.00	0.01	0.16	0.29
Calf sex[6]	0.54	0.02	0.49	0.03	0.10	0.80

[1]*P*-value significance of calving system

[2]*P*-value significance of age of cow

[3]Adjusted 205 d weaning weight

[4]Calving difficulty score on scale of 1 to 5: 1 = unassisted, 2 = easy pull, 3 = hard pull, 4 = surgical removal, 5 = abnormal presentation

[5]Vigor of the calf shortly after birth on scale of 1 (nursed immediately, strong) to 5 (dead on arrival)

[6]Average sex of calf born in herd (0 = female, 1 = male)

Weaning rates were similar between both systems, but the March-born calves had approximately 70 lb increased weaning weights over June-born calves of similar age. June was selected in this region to best match cow nutrient needs with nutrients in grazed forages. The current study was conducted to provide information on a May calving system as May was selected to balance the differences/downfalls between the March and June systems.

Procedure

Data from 3 production years from 2 calving herds in the Nebraska Sandhills were analyzed. Red Angus-based cows from the Gudmundsen Sandhills Laboratory, Whitman, NE, calved either in March or May. All cows analyzed were at least 3 yr of age or older. The numbers varied each year for March (n = 194, n = 160, and n = 149 for yr 1, 2, and 3 respectively) and May (n = 105, n = 106, and n = 90 for yr 1, 2, and 3 respectively) calving herds. Average calving date was March 24 for the March herd and June 5 for the May herd. March cows calved in a drylot and May cows calved on native range.

All steer calves from the March herd entered the feedlot after a 14 d weaning period as calf-feds. May-born steer calves were backgrounded for approximately 136 d. After backgrounding, half of the steers entered the feedlot as calf-feds and the remainder grazed native upland range for approximately 129 d before entering the feedlot as yearling-feds. All steers were harvested when visually assessed to have approximately 0.5 in backfat depth and carcass quality data was collected.

Results

In the March calving system, 82% of the calves were born in the first 21 d; while 85% of the May calves were born within the first 21 d. Calf birth BW and calf BW at breeding were ($P < 0.01$) greater for May calves vs. March (78 ± 0.6 lb vs. 77 ± 0.5 lb and 214 ± 2 lb vs. 173 ± 1.6 lb respectively); however, adjusted weaning BW was greater ($P < 0.01$) for March calves (500 ± 2.5 lb vs. 426 ± 4.4 lb, March vs. May, respectively; Table 1). Pregnancy rates (89% vs. 91%), weaning rates (96% vs. 94%), calving interval, calving difficulty, and calf vigor were similar ($P > 0.10$) between systems. Udder

Table 2. Comparison of cow performance between March and May calving systems

					P-value	
	March	SEM	May	SEM	System[8]	Cow Age[9]
n	503		301			
Cow Age[1]	5.83	0.08	4.70	0.08	-	-
Calving wt, lb	1,107.84	6.30	1,012.78	6.50	0.01	0.01
Calving BCS[2]	5.18	0.03	4.87	0.03	0.01	0.13
Breeding wt, lb	1,033.77	5.64	1,079.10	7.37	0.01	0.01
Breeding BCS	4.90	0.03	5.74	0.03	0.01	0.01
Wean wt, lb	1,101.27	5.53	972.96	7.55	0.01	0.01
Wean BCS	5.37	0.03	4.70	0.04	0.01	0.01
Preg[3]	0.91	0.01	0.89	0.02	0.74	0.16
Calving Rate[4]	0.98	0.01	1.00	0.00	0.05	0.46
Wean Rate[5]	0.94	0.01	0.96	0.01	0.64	0.17
Julian DOB[6]	82.60	0.56	145.37	0.59	-	-
Udder Score[7]	3.32	0.03	3.01	0.05	0.01	0.06

[1]Average age of cows in the herd

[2]Body condition score based on scale of 1 (emaciated) to 9 (extremely obese)

[3]Percentage of cows pregnant that were given opportunity to breed

[4]Percentage of cows that gave birth to a calf that were diagnosed as pregnant

[5]Percentage of cows that weaned a calf of those who gave birth to a calf

[6]Average calving date of herd based on Julian calendar

[7]Average udder score of cow at calving on scale of 1 (poor) to 5 (exceptional)

[8]*P*-value of calving system

[9]*P*-value of age of cow

score was greater ($P < 0.01$) for March cows (3.32 ± 0.03 vs. 3.01 ± 0.05, March vs. May, respectively; Table 2).

Compared with March calf-fed steers, May calf-fed steers had greater ($P < 0.01$) HCW (898 ± 12 lb vs. 830 ± 5 lb), LMA (15 ± 0.2 in^2 vs. 14 ± 0.1 in^2), marbling (494 ± 12 vs. 477 ± 5.9), and backfat (0.65 ± 0.02 in vs. 0.57 ± 0.01 in). May yearling steers had greater ($P < 0.01$) HCW (961 ± 13.2 lb vs. 830 ± 4.7 lb), LMA (15 ± 0.2 in^2 vs. 14 ± 0.1 in^2), marbling (566 ± 15 vs. 477 ± 5.9), and backfat (0.66 ± 0.03 in vs. 0.57 ± 0.01 in) compared with March calf-feds. May steers likely finished with increased HCW and carcass traits due to increased backgrounding period compared to March steers.

Conclusion

Selection of calving season is best assessed by each producer at his/her own location. Management decisions for steers and replacement heifers will vary between systems as this study illustrated briefly the flexibility post weaning depending on forage availability and time of year. Peak forage nutrients vary as well as complementary forages and access to stockpiled feeds. By synchronizing peak nutrient requirement of the cow with peak forage quality, a producer can mitigate cost and amount of forage used per cow and increase potential for profitability. In the Sandhills, a May calving system can increase production while reducing total herd inputs when compared to a March calving system.

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Evaluating Syngenta Enogen Feed Corn Silage or Grain on Growing Beef Cattle Performance

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Summary with Implications

A growing trial was conducted to evaluate Syngenta Enogen Feed Corn containing an alpha amylase enzyme trait compared with commercially available corn without the amylase enzyme trait on growing cattle performance characteristics. Corn was harvested as either corn silage or dry corn, and corn silage was further harvested with kernel processing or not. The treatment design was a 2×2+2 factorial with 2 hybrids of silage, kernel processed or not, and then a 40% dry-rolled corn and hay growing diet as Syngenta Enogen Feed Corn or control corn. No interactions were observed between silage hybrids and kernel processing. Cattle fed kernel processed silage had a 6.5% improvement in feed conversion compared to not kernel processed silage. No statistical differences were observed when feeding Syngenta Enogen Feed Corn as dry-rolled corn compared to control dry-rolled corn. There was no benefit of the Syngenta Enogen Feed Corn when fed as corn silage or dry-rolled corn when used in growing rations.

Introduction

To maximize feed conversion in beef cattle, starch digestion must be optimized. Syngenta Enogen Feed Corn (EFC; Syngenta Seeds, LLC) has been genetically enhanced to contain an α-amylase enzyme trait. Previous research has observed a decrease in F:G and an increase in post-ruminal starch digestion when EFC was fed as DRC, compared to corn not containing the α-amylase enzyme trait (*2018 Nebraska Beef Cattle Report*, pp. 92–94; *2016 Nebraska Beef Cattle Report*, pp. 135–138; *2016 Nebraska Beef Cattle Report*, pp. 143–145).

Feeding corn silage allows cattle feeders to take advantage of the entire corn plant at a time of maximum quality and tonnage as well as secure substantial quantities of roughage/grain inventory (*2013 Nebraska Beef Cattle Report*, pp. 74–75). Incorporating corn silage based growing diets containing 80% corn silage in combination with distillers grains has been shown as a potentially economical and efficient way to grow steers prior to the finishing phase (*2011 Nebraska Beef Cattle Report*, pp. 16–17).

Therefore, the objective of this study was to compare EFC corn to commercially available corn without the alpha amylase enzyme trait when used as a silage, and also how EFC grain will work in non-silage, forage-based diets such as hay.

Table 1. Dietary treatment compositions (DM basis) for growing steers fed Enogen or control hybrids as kernel processed silage or not processed compared to both hybrids as dry-rolled corn.

Ingredient, % DM	Corn Silage				Dry-rolled Corn	
Corn Trait	CON[1]		EFC[2]		CON[1]	EFC[2]
Kernel Processing	KP	NKP	KP	NKP	-	-
CON KP Corn Silage[1]	80.0	-	-	-	-	-
CON NKP Corn Silage[1]	-	80.0	-	-	-	-
EFC KP Corn Silage[2]	-	-	80.0	-	-	-
EFC NKP Corn Silage[2]	-	-	-	80.0	-	-
CON Dry-rolled Corn[1]	-	-	-	-	40.0	-
EFC Dry-rolled Corn[2]	-	-	-	-	-	40.0
Grass Hay	-	-	-	-	40.0	40.0
Modified Distillers Grains	15.0	15.0	15.0	15.0	15.0	15.0
Supplement[3]	5.0	5.0	5.0	5.0	5.0	5.0
Fine Ground Corn	2.099	2.099	2.099	2.099	2.099	2.099
Limestone	1.5	1.5	1.5	1.5	1.5	1.5
Urea		0.9	0.9	0.9	0.9	0.9
Salt		0.3	0.3	0.3	0.3	0.3
Tallow		0.125	0.125	0.125	0.125	0.125
Beef Trace Mineral		0.05	0.05	0.05	0.05	0.05
Vitamin ADE		0.015	0.015	0.015	0.015	0.015
Rumensin 90		0.01102	0.01102	0.01102	0.01102	0.01102

[1]CON= Commercially available corn grain without the alpha amylase enzyme trait

[2]EFC = Syngenta Enogen Feed Corn provided by Syngenta under identity-preserved procedures, stored, processed as corn silage or dry-rolled corn (DRC), and fed separately

[3]Supplement formulated to provide 200mg/steer daily Rumensin® (Elanco Animal Health, DM Basis)

Procedure

An 84-d growing study, utilizing 576 crossbred steers (BW = 674 lb; SD = 51 lb) in a randomized block design, was conducted at the Eastern Nebraska Research and Extension Center (ENREC) feedlot near Mead, NE. Steers were limit fed a diet consisting of 50% alfalfa hay and 50% Sweet Bran (Cargill; Blair, NE) at 2.0% BW for 5 consecutive days to equalize gut fill. Steers were weighed on 2 consecutive days and the average of those 2 days was used as initial BW. Cattle were implanted with Ralgro®

Table 2. Effect of corn silage variety and kernel processing on growing cattle performance.

	Corn Silage[7]				Dry-rolled Corn[8]		*P*-Values					
	CON[1]		EFC[2]		CON[1]	EFC[2]						
Performance	-KP	+KP	-KP	+KP	-	-	SEM	F-Test	Main Hybrid[3]	Main KP[4]	Int.[5]	EFC as DRC[6]
Initial BW, lb	675	673	674	675	675	675	0.8	0.28	0.43	0.76	0.03	0.87
Ending BW, lb	991	995	982	997	966	966	4.7	<0.01	0.44	0.06	0.28	0.96
DMI, lb/d	21.6	20.7	21.6	21.7	24.6	24.1	0.27	<0.01	0.06	0.12	0.06	0.24
ADG, lb	3.77	3.83	3.67	3.82	3.47	3.47	0.06	<0.01	0.36	0.06	0.46	0.92
Feed:Gain	5.74	5.39	5.89	5.68	7.09	6.94	-	<0.01	<0.01	<0.01	0.19	0.37

[1]CON= Commercially available corn grain without the alpha amylase enzyme trait

[2]EFC = Syngenta Enogen Feed Corn provided by Syngenta under identity-preserved procedures, stored, processed as corn silage.

[3]Effect of corn silage variety.

[4]Effect of kernel processing.

[5]Interaction effects of corn silage and kernel processing.

[6]Effect of Syngenta Enogen Feed Corn as dry-rolled corn.

[7]Corn silage included in the diet at 80%, 15% MDGS, 5% supplement.

[8]Dry-rolled corn included in the diet at 40%, 40% grass hay, 15% MDGS, 5% supplement.

(Merck Animal Health) on d 1. Steers were blocked by BW into light, medium, and heavy BW blocks (n= 2, 4, and 2 replicates, respectively) based on d 1 BW, stratified by BW and assigned randomly to 1 of 48 pens with pens assigned randomly to 1 of 6 treatments. There were 12 steers/pen and 6 replications/treatment.

Dietary treatments (Table 1) were arranged in a 2×2+2 factorial, and included 1) conventional commercial corn silage with kernel processing (CON KP), 2) CON corn silage without kernel processing (CON NKP), 3) Syngenta Enogen Feed Corn silage with kernel processing (EFC KP), 4) EFC silage without kernel processing (EFC NKP), 5) CON dry-rolled corn with grass hay (CON DRC), and 6) EFC dry-rolled corn with grass hay (EFC DRC). Diets were formulated to meet or exceed NRC requirements for protein and minerals. The final growing diets provided 200 mg/steer daily of Rumensin (Elanco Animal Health). Ending BW was determined similarly to initial BW. Steers were limit fed a diet consisting of 50% alfalfa hay and 50% Sweet Bran (Cargill; Blair, NE) at 2.0% BW for 5 consecutive days and weighed 2 consecutive days. Ending BW was calculated by averaging the 2-d weights.

Performance (BW, DMI, ADG, F:G) data were analyzed using the MIXED procedure of SAS (SAS Inst., Inc., Cary, N.C.) with pen as the experimental unit. Data were analyzed as a 2×2+2 factorial. Within corn silage, the interaction was tested between corn trait and kernel processing. If no interaction was detected, than main effects will be discussed. If an interaction occurred, than simple effects of kernel processing within corn silage trait will be discussed. A preplanned pairwise comparison was made between hybrids when fed at 40% of the diet as DRC.

Results

No interactions between corn silage hybrid and kernel processing were observed for ending BW, ADG, or feed efficiency ($P \geq 0.19$; Table 2). A tendency for an interaction was observed for DMI ($P = 0.06$) where steers fed CON KP silage tended to consume less than CON NKP or either EFC silage. Due to no interaction being observed, main effects of corn silage hybrid and kernel processing were tested. For the main effects of corn silage hybrid (Table 3), DMI was lower for cattle fed the CON silage than EFC ($P = 0.01$), while average daily gain did not differ ($P = 0.29$), thus, steers fed the CON silage had a lower F:G compared to those fed EFC ($P < 0.01$). Steers fed kernel processed silage had greater ending BW than those fed silage that was not kernel processed ($P = 0.03$; Table 4). Additionally, cattle fed kernel processed silage displayed decreased DMI ($P = 0.05$) and increased ADG ($P = 0.03$) than those consuming non-processed silage. Due to decreased DMI, and increased ADG, F:G was lower for cattle fed kernel processed silage ($P < 0.01$). Kernel processing corn silage when fed at 80% of the diet appears to have a positive effect on feed efficiency of growing steers, when compared to non-kernel processed silages. Feeding kernel processed silage resulted in a 5.2% improvement in efficiency when diets included silage at 80%, suggesting the silage was improved by 6.5% (5.2/0.80) compared to not kernel processing silage.

Control and EFC DRC when included at 40% of the diet with 40% grass hay were not statistically different from one another for any of the performance characteristics ($P \geq 0.37$; Table 2). Cattle fed EFC DRC had numerically lower DMI (0.50 lb/day less) than those fed CON DRC ($P = 0.24$). Therefore, F:G was numerically lower for the cattle fed EFC DRC (6.94) than those fed CON DRC (7.04; $P = .37$). These results suggest that EFC DRC had no statistical benefit over the CON DRC.

Conclusion

Feeding growing cattle Syngenta Enogen Feed Corn silages did not improve any of the performance characteristics when compared to traditional silage, when fed at 80% of the diet. Traditional corn silage had lower DMI, greater ADG, and F:G. Using kernel processing in corn silage did not interact with the hybrid type. However, kernel processing improved feed efficiency by 5.2% when fed at 80% inclusion (DM), suggesting a 6.5% improvement in the silage as a

Table 3. Main effect of corn silage hybrid on cattle performance.

	Treatment			
Item	CON[1]	EFC[2]	SEM	*P*-value[3]
Pens	16	16		
Performance				
Initial BW, lb	674	674	0.6	0.48
Ending BW, lb	994	990	2.9	0.37
DMI, lb/d	21.1	21.7	0.15	0.01
ADG, lb	3.80	3.76	0.03	0.29
Gain:Feed	0.181	0.174	0.002	<0.01
Feed:Gain	5.55	5.77	-	<0.01

[1]CON= Commercially available corn grain without the alpha amylase enzyme trait

[2]EFC = Syngenta Enogen Feed Corn provided by Syngenta under identity-preserved procedures, stored, processed as corn silage.

[3]P-value for the main effect of corn silage hybrid

Table 4. Main effect of kernel processing on cattle performance.

	Treatment[1]			
Item	+KP	-KP	SEM	*P*-value[2]
Pens	16	16		
Performance				
Initial BW, lb	674	674	0.6	0.79
Ending BW, lb	996	987	2.9	0.03
DMI, lb/d	21.2	21.7	0.15	0.05
ADG, lb	3.84	3.73	0.03	0.03
Gain:Feed	0.182	0.173	0.002	<0.01
Feed:Gain	5.52	5.80	-	<0.01

[1]Treatments were kernel processed (+KP) or not kernel processed (-KP)

[2]P-value for the main effect of kernel processing

feed. Furthermore, feeding growing cattle Syngenta Enogen Feed Corn as dry-rolled corn did not have any effect on performance characteristics when compared to traditional dry-rolled corn, when fed at 40% of the diet with 40% grass hay.

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Evaluation of Masters Choice Corn Silage on Growing Steer Performance

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Summary with Implications

A growing study evaluated three corn silage hybrids on growing steer performance. The three hybrids were: a conventional hybrid-Farm Choice (CON) commonly grown in Eastern Nebraska which served as the control, Masters Choice hybrids MCT6365 RIB (MC1) selected to improve fiber and starch digestion and MCT6733 GT3000 (MC2) that has been selected to improve fiber digestion in cattle. Relative to CON, feeding hybrid MC1 resulted in similar DMI, but numerically increased ADG which significantly improved F:G compared to CON. Feeding MC2 led to greater DMI, similar ADG, and poorer (greater) F:G compared to CON. Feeding Masters Choice hybrid MCT6365 RIB (MC1) corn silage at 80% of the diet DM likely improved digestion and energy availability to the steers, which allowed greater ADG and improved F:G, while the opposite was true for MC2. Differences in hybrids exist when fed to growing cattle at 80% of the diet.

Introduction

Previous research has shown an economic incentive to feeding cattle diets with elevated levels of corn silage when feed costs are high. When increased levels of corn silage are fed in corn-based finishing diets, NEm and NEg values of the ration are depressed. In recent studies completed at UNL, feeding 30 to 45% corn silage was more economical than lower silage inclusions, despite slightly poorer feed conversions. Methods that improve feed conversion when silage is elevated in diets will make corn silage even more logical for backgrounding and feeding operations. Hybrids may be selected for differences in traits that may lead to better digestion, which should impact performance. Most previous evaluations of hybrid impact on corn silage use by beef and dairy cattle relies on laboratory testing. Those techniques may or may not predict actual performance when fed.

Therefore, the objective of this experiment was to evaluate two Masters Choice hybrids that have been selected to improve fiber plus starch digestion (MC1) and fiber digestion (MC2) in cattle (based on laboratory assays). These Masters Choice hybrids were compared to a hybrid commonly grown in Eastern Nebraska.

Procedure

Three hybrids of corn silage were grown and harvested at the Eastern Nebraska Research and Extension Center (ENREC) near Mead, NE. The three hybrids were a hybrid-Farm Choice (CON) commonly grown in Eastern Nebraska which served as the control, Masters Choice hybrids MCT6365 RIB (MC1) and MCT6733 GT3000 (MC2) that have been selected to improve fiber plus starch digestion (MC1) and fiber digestion (MC2) in cattle. Corn silage was targeted at 37–38% DM for green chop at harvesting and was harvested from Aug 27th through Aug 29th, 2018. Corn silages were stored in Silage Bags (Up North Plastics, Cottage Grove, MN) on a concrete pad until the initiation of the trial on Feb 13, 2019. Corn silage samples were collected for fermentation analysis prior to, middle, and end of the growing trial to ensure proper ensiling. All feeds were sampled weekly for DM and monthly composites analyzed for nutrients. Weekly corn silage samples were sent to commercial lab for yeast and mold counts.

An 84-day growing trial was conducted utilizing 288 crossbred steers (initial BW = 667 ± 27 lb). All steers were limit-fed a common diet consisting of a 50:50 blend of alfalfa hay and SweetBran (Cargill, Blair, NE) on a DM basis at 2% of BW for five days prior to trial initiation to minimize variation in gut fill. Following five days of limit feeding, steers were weighed for two consecutive days and the two-day weights averaged for initial BW. Cattle were stratified by BW (two blocks: light and heavy) and assigned randomly to pens with 12 head per pen. Pens were assigned randomly to one of the three treatments, with 8 pens per treatment. Steers were implanted with Ralgro (Merck Animal Health) during initial processing.

The three treatments (Table 1) were set up in a generalized randomized block design. All diets (DM basis) included 15% modified distillers grains plus solubles (MDGS), 5% supplement, and 80% of respective corn silage for that treatment (CON, MC1 or MC2). Monensin was added in the supplement to supply 200 mg/steer daily of Rumensin (Elanco Animal Health). Diets were formulated to ensure protein and nutrient requirements were met so any performance differences would be due to energetic differences between the different silage treatments. Steers were fed once daily in the morning and bunks were scooped and orts weighed as necessary and at the end of the growing trial to adjust for DMI. Ending BW was collected similar to initial BW with steers limit-fed at 2% of BW of 50:50 alfalfa hay and SweetBran diet for five days and weighed for two consecutive days.

Performance data (BW, DMI, ADG and F:G) were analyzed using the MIXED procedure of SAS 9.4 (SAS Institute, Inc., Cary, NC, USA) with pen serving as experimental unit. Block was included in the model as a fixed effect.

Results

After fermentation, DM declined slightly to 35–36% (Table 2). The fermentation analysis of the three corn silage hybrids indicated adequate and similar ensiling occurred between hybrids as pH was below

Table 1. Diets (DM basis) fed to growing steers for 84 days to evaluate the use of Masters Choice silage or conventional hybrid.

	Treatment[1]		
Ingredients, %	CON	MC1	MC2
Corn Silage-CON	80	-	-
Corn Silage-MC1	-	80	-
Corn Silage-MC2	-	-	80
MDGS[2]	15	15	15
Supplement[3]	5	5	5

[1] CON, corn hybrid of Farm Choice silage containing diet serves as control; MC1, corn hybrid of MCT6365 RIB silage containing diet, selected for greater fiber + starch digestion; MC2, corn hybrid of MCT6733 GT3000 silage containing diet, selected for greater fiber digestion

[2] MDGS, modified distillers grains plus solubles

[3] Supplement consisted of 2.79% fine ground corn, 1.21% limestone, 0.125% tallow, 0.50% urea, 0.30% salt, 0.05% trace mineral package (10% Mg, 6% Zn, 4.5% Fe, 2% Mn, 0.05% Cu, 0.3% I and 0.05% Co), 0.015% vitamin A-D-E package (1,500 IU of vitamain A, 3,000 IU of vitamin D, 3.7 IU of vitamin E) as percentages of the final diets (DM basis) and Rumensin to provide 200 mg/steer daily (assuming a DMI of 22 lb)

Table 2. Nutrient and fermentation analysis of three corn silage hybrids

		Hybrids[1]		
Item[2]	Goal	CON	MC1	MC2
DM[3], %		35.67	36.72	36.11
CP, % of DM		8.10	8.22	8.48
NDF, % of DM		33.43	34.20	36.60
ADF, % of DM		21.37	20.17	22.00
pH, as sampled	< 4	3.97	4.00	3.93
Lactic Acid, % of DM	> 4	4.94	3.82	4.28
Acetic Acid, % of DM	< 3	3.58	4.85	2.91
Lactic/Acetic Ratio	1.6–3.0	1.38	0.84	2.34
Propionic Acid, % of DM	< 1	0.80	1.18	0.46
Butyric Acid, % of DM	< 0.1	0.06	0.11	0.01
IsoButyric, % of DM		0.01	0.01	0.01
Total Acids, % of DM	7.0–12.0	9.39	9.97	7.66
Ammonia, CPE% of DM		0.64	0.73	0.53
Ammonia-N, % of Total N	8.0–15.0	7.89	9.01	6.00
VFA Score	6.0–10.0	7.61	7.09	7.35

[1] CON, corn hybrid of Farm Choice silage serves as control; MC1, corn hybrid of MCT6365 RIB silage, selected for greater fiber + starch digestion; MC2, corn hybrid of MCT6733 GT3000 silage, selected for greater fiber digestion

[2] All values except DM content were averages of three samples took before the bag opening, at the middle and at the end of the feeding period

[3] DM content of each silage was averaged from 12 weekly samples during the whole feeding periods

Table 3. Effect of Masters Choice corn silage hybrids on growing performance of beef steers.

	Treatments[1]				
Variable	CON	MC1	MC2	SEM	*P*-value
Initial BW, lb	667	667	667	0.7	0.99
Ending BW, lb	1001[ab]	1011[a]	995[b]	5.1	0.10
DMI, lb/d	22.7[b]	22.5[b]	24.0[a]	0.141	<0.01
ADG, lb	3.98[ab]	4.11[a]	3.92[b]	0.058	0.09
F:G	5.71[b]	5.48[a]	6.13[c]	0.065	<0.01

[a–c] Means within a row with different superscripts differ ($P < 0.05$).

[1] CON, corn hybrid of Farm Choice silage containing diet serves as control; MC1, corn hybrid of MCT6365 RIB silage containing diet, selected for greater fiber + starch digestion; MC2, corn hybrid of MCT6733 GT3000 silage containing diet, selected for greater fiber digestion

4.0 and total acids was at least 7.0%. Fiber, protein, and DM contents appear similar but silage storage is not replicated so nutrient differences are not analyzed statistically.

Ending BW and ADG tended ($P \leq 0.10$) to be impacted by silage hybrid (dietary treatment) while DMI and F:G were impacted by corn silage hybrid fed ($P < 0.01$). Ending BW of steers fed MC1 tended to be greater than CON ($P = 0.15$) and was greater than MC2 ($P = 0.04$), while ending BW of steers fed MC2 and CON were not significantly different ($P = 0.46$, Table 3). Intake of steers fed MC1 did not differ ($P = 0.28$) from steers fed CON, whereas steers fed MC2 had greater ($P < 0.01$) DMI compared to CON and MC1. Average daily gain (ADG) of steers fed MC1 tended to be greater than CON steers ($P = 0.14$) and was greater than steers fed MC2 ($P = 0.03$), with no difference between steers fed MC2 and CON ($P = 0.45$). With numerically lower intake and greater ADG, F:G of steers fed MC1 was improved ($P \leq 0.02$) compared to steers fed CON and MC2. Steers fed MC2 had the poorest F:G which was greater than steers fed CON ($P < 0.01$).

The yeast count (Table 4) of the three corn silage samples during the feeding period stayed low and constant with no difference between hybrids. The mold count of MC2 corn silage tended to be increased as time went and was greater than hybrids CON and MC1, especially in week 6, 7 and 8 of the feeding periods. Two bags of each silage were ensiled due to quantity. On week 9, the MC2 bag was switched to the new bag. The mold count of CON and MC1 corn silage were similar through the feeding period. Mold, due to storage conditions in this study, might impact nutrient content and digestibility of corn silage thus compromise animal performance, but was unlikely in this trial.

Conclusions

Feeding Masters Choice corn silage hybrid MCT6365 RIB (MC1) that has been selected for improved starch and fiber digestion at 80% of the diet DM improved ADG and F:G when compared to the other corn silage hybrids grown in Eastern Nebraska. Slightly less intake, greater ADG and improved feed efficiency indicates digestion and energy availability of corn

Table 4. Yeast and Mold counts[1] of corn silage sample on different date

	Hybrids[2]					
	CON		MC1		MC2	
Sample Date[3]	Yeast	Mold	Yeast	Mold	Yeast	Mold
2/18/2019	<10	<10	<10	<10	<10	<10
2/25/2019	<10	<10	<10	<10	<10	<10
3/4/2019	<10	<10	<10	10	<10	50
3/11/2019	<10	20	<10	40	<10	80
3/18/2019	<10	<10	<10	<10	<10	10
3/25/2019	<10	<10	<10	<10	<10	2200
4/1/2019	<10	<10	<10	<10	<10	1800
4/8/2019	<10	<10	<10	<10	<10	300
4/15/2019	<10	30	<10	<10	<10	<10
4/22/2019	<10	20	<10	120	<10	<10
4/29/2019	<10	40	<10	20	<10	60
5/6/2019	<10	<10	<10	10	<10	<10

[1] All results are reported on an AS RECEIVED basis (cfu/g), cfu = colony forming unit

[2] CON, corn hybrid of Farm Choice silage serves as control; MC1, corn hybrid of MCT6365 RIB silage, selected for greater fiber + starch digestion; MC2, corn hybrid of MCT6733 GT3000 silage, selected for greater fiber digestion

[3] MC2 sampled on and before 4/8/2019 were before switching to backup storage bag, MC2 sampled on and after 4/15/2019 were from the backup silage bag; samples of CON and MC1 were all from the original bags

silage was improved when cattle were fed MC1, which could be beneficial in reducing total feed cost and make corn silage feeding more appealing to cattle feeders. These data suggest that corn hybrid selection can impact cattle performance when fed.

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Growth and Performance of Terminal Sired Calves Grazing Range or Meadow Pasture

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Summary with Implications

Multiparous dams were assigned to be bred by artificial insemination or natural service to bulls with terminal traits. Additionally, the cow-calf pairs grazed upland range or sub-irrigated meadow from June 1 to weaning in November. Two weeks after weaning, calves entered the feedlot as calf-feds. Natural service range calves had the lightest weaning weights, final live weights, and hot carcass weights. Additional days on feed may be required for natural service range calves to reach similar body weights and carcass characteristics as other treatments. Average daily gain and feed conversion was improved in calves that grazed range pastures prior to feedlot entry. Estrus synchronization and artificial insemination may be an effective way to increase body weights and carcass characteristics of calves that graze range pastures prior to feedlot entry.

Introduction

Ideally, there are two distinct breeding objectives within the cow-calf sector: terminal or maternal. Terminal breeding objectives are focused on growth rate targeted to a desired endpoint, feed intake, increased carcass quality, and male fertility. Maternal breeding objectives focus on longevity, moderate size, adaptation to the production environment, milk production, maternal instinct, and female fertility. Terminal and maternal breeding traits can be antagonistic as retaining replacement females from sires with desirable terminal traits could increase cow size thereby increasing nutrient requirements and potentially decrease profits (*2010 Nebraska Beef Cattle Report*, pp. 29–30). As cost of production increases, it is important to select genetics suitable to the production environment (*2019 Nebraska Beef Cattle Report*, pp. 21–23). The environment within the Nebraska Sandhills is comprised of native upland range and sub-irrigated meadow pastures with distinct nutrient profiles (*1997 Nebraska Beef Cattle Report*, pp. 3–5). Producers should have a distinct breeding objective that matches their production environment to maximize profit. Therefore, the objective of this study was to evaluate the growth and performance of calves sired by terminal bulls grazing upland range or sub-irrigated meadow pastures and their subsequent feedlot performance.

Procedure

Dam Management

One hundred twenty-four Simmental × Red Angus crossbred March-calving cows from the Nebraska Ranch Practicum teaching herd at the Gudmundson Sandhills Laboratory (GSL) were utilized in this study. Cows were randomly assigned within cow age, ranging from 3 to 11 years old, to be bred to a terminal bull by artificial insemination (AI) or terminal bulls used for natural service (NS). Additionally, cows were assigned to graze either upland range (RNG) or sub-irrigated meadow (MDW) from June 1 until weaning in November. Bull selection was based off a terminal index; a composite of economically relevant traits focused on growth and carcass characteristics. Dams remained in their respective treatment for the duration of the study. Treatments were assigned 1 yr prior to data collection. Dams were diagnosed for pregnancy on September 5 via transrectal ultrasonography (Aloka, Hitachi Aloka Medical America Inc., Wallingford, CT) and overwintered as a single cohort on MDW pasture and supplemented with meadow hay (7 to 7.5% crude protein). After calving, cows were supplemented with hay and 1 lb of dried distillers grain-based supplement (27% crude protein) until May 15.

Dams allotted to AI were synchronized using the 7 d Co-Synch + controlled internal drug release (CIDR) protocol. On d 0 cows received a 2-mL i.m. injection of gonadotropin-releasing hormone (GnRH; Factrel; 100μg gonadorelin hydrochloride; Zoetis Animal Health, Parsippany, NJ) and a CIDR (EAZI-BREED CIDR; 1.35 g progesterone; Zoetis Animal Health, Parsippany, NJ). On d 7, CIDRs were removed and cows received a single injection of prostaglandin. Sixty to sixty-six hours later, cows received a 2-mL i.m. injection of GnRH and were inseminated. Dams assigned to AI were bred to a black, half-blood Simmental × Angus bull with a terminal index of 82.6 which ranks him in the top 5% of his breed. Clean-up bulls were placed with the AI dams 7 d after AI on June 10 and remained with the cows until July 20. Sixty-seven percent of the dams conceived to AI; therefore, data from AI dams that did not conceive to AI were removed from the analysis.

Bull placement for the NS breeding treatment coincided with AI on June 3. Dams assigned to the NS breeding treatment were not synchronized. Crossbred Simmental × Red Angus bulls, with an average terminal index of 70.4 which collectively ranks them in the top 43% according to their breed. Bulls remained with the NS dams for a 45 d breeding season. The average bull to cow ratio over the 3 yr of the study was 1:16.

Calf Management

At birth, calves received a 7-way clostridial vaccine (Alpha 7, Boehringer Ingelheim, Duluth, GA). At branding in April, bull calves were castrated and all calves received vaccinations for infectious bovine rhinotracheitis, bovine viral diarrhea types I and II, bovine

Table 1. Effect of artificial insemination (AI) or natural service (NS) and upland range (RNG) or sub-irrigated meadow (MDW) grazing on post-natal calf growth

	TREATMENT					*P*-value[1]		
	AI-MDW	AI-RNG	NS-MDW	NS-RNG	SEM	BRD	GRZ	B × G
n	24	18	31	30				
Body Weight, lb								
Birth	83	89	82	80	3.27	0.16	0.44	0.15
May	191	192	191	186	5.92	0.63	0.72	0.52
June	253	252	258	247	7.91	0.99	0.34	0.48
July	340	329	352	326	11.8	0.69	0.06	0.44
Sep	492[ab]	502[ab]	513[a]	474[b]	15.5	0.84	0.26	0.05
Weaning WDA[2], lb/d	2.77[a]	2.70[a]	2.80[a]	2.53[b]	0.09	0.29	<0.01	0.09
Weaning	617[a]	601[a]	622[a]	564[b]	15.5	0.30	<0.01	0.09
205[3]-d	490	471	496	443	12.7	0.40	<0.01	0.11

[ab] Means within a row with dissimilar superscripts are significantly different ($P < 0.10$).

[1]BRD = breeding treatment main effect, GRZ = grazing treatment main effect, B × G = breeding × grazing treatment interaction.

[2]WDA = weight per day of age.

[3]Common age 205 d weaning weight.

parainfluenza virus-3, bovine respiratory syncytial virus, Mannheimia haemolytica, and Pasteurella multocida (Vista Once SQ, Merck, Kenilworth, NJ); and a 7-way clostridial vaccine (Vision 7, Merck, Kenilworth, NJ). At weaning in November, all calves received one dose of Vista Once SQ and a second dose 14 d later. A 7-way clostridial vaccine with somnus (Vision 7 Somnus, Merck, Kenilworth, NJ) was also given at this time.

Calf body weight (BW) was measured at birth, May, June, July, September, and at weaning. A common age 205 d weaning weight (WW) was calculated using the formula: ([WW- birth BW]/[Julian d of age at weaning—Julian d of birth] ×205 = 205 d avg. WW). Calves remained at GSL for 2 wk after weaning in a drylot and received *ad libitum* hay. Calves were then transported to the feedlot at the West Central Research and Extension Center (WCREC), North Platte.

Post-weaning Calf Management

Steer and heifer calves entered the WCREC feedlot in mid-November as calf-feds. Calves were weighed, received an electronic identification tag, implanted with Synovex Choice (Zoetis Animal Health, Parsippany, NJ) and were separated into pens by sex. Head per pen ranged from 18 to 30 head over the 3 yr of the study. Calves were started on a diet consisting of 20% dry-rolled corn, 35% prairie hay, 35% wet corn gluten feed and 10% supplement (dry matter basis). Over 21 d, calves were adapted to a common finishing diet consisting of 48% dry-rolled corn, 7% ground prairie hay, 38% wet corn gluten feed and 7% supplement (dry matter basis). Diets were fed *ad libitum* throughout the feeding period. Calves were re-implanted approximately 105 d prior to harvest with Synovex Plus (Zoetis Animal Health, Parsippany, NJ). A pour on insecticide was also given at this time (Clean-Up II, Bayer Animal Health, Kansas City, MO). Diets were fed twice daily and individual feed intakes were recorded using a GrowSafe feeding system (GrowSafe Systems Ltd., Airdrie, AB, Canada) after diet adaptation period until 1 d prior to slaughter and was used to measure dry matter intakes (DMI). Body weights were measured on December 13 and 14, and the average of both weights was used for the initial BW. Final BW was calculated using hot carcass weights (HCW) adjusted to a common dressing percentage of 63%. Initial BW and Final BW were used to calculate average daily gain (ADG) and feed to gain (F:G) over the 182 d feeding period. All calves were finished to similar days on feed.

Calves were harvested in mid-June each year (Tyson Fresh Meats, Lexington, NE). Carcass data were collected 24 h following harvest. Carcass data included HCW, backfat (BF), calculated yield grade (YG), *longissimus* muscle area (LMA), and marbling.

Statistical analysis

Data were analyzed as a 2 × 2 factorial with factors being breeding system (AI or NS) and grazing treatment (RNG or MDW) using the PROC MIXED procedure of SAS (SAS Inst. Inc., Cary, NC, version 9.4). Individual calf was considered the experimental unit. The model included year and sex as fixed effects and Julian birthdate was included as a covariate. A *P*—value < 0.10 was considered significant.

Results

Pre-Weaning Calf Growth

Calf growth during the grazing period is reported in Table 1. Breeding and grazing treatments did not affect calf BW at birth, May, or in June ($P \geq 0.12$). Grazing treatment impacted calf BW in July, weaning weight per day of age, and adjusted 205 d average weaning weight ($P \leq 0.06$) with calves grazing MDW weighing more than calves grazing RNG. A breeding × grazing treatment interaction was observed for calf BW in September and at weaning. In September, NS-MDW calves had the greatest BW, AI-RNG and AI-MDW were intermediate, and NS-RNG had the lightest BW ($P = 0.05$). At weaning, NS-RNG calves had the lightest BW ($P \leq 0.09$); all other treatment groups had similar BW. Previous research conducted at the same location from 2015 to 2018 utilizing bulls with maternal

Table 2. Effect of artificial insemination (AI) or natural service (NS) breeding and upland range (RNG) or sub-irrigated meadow (MDW) grazing on feedlot performance of calf-feds[1]

	TREATMENT					*P*-value[2]		
	AI-MDW	AI-RNG	NS-MDW	NS-RNG	SEM	BRD	GRZ	B × G
% Steers	50	55	45	53				
Arrival BW[3], lb	599	573	599	533	15.7	0.21	<0.01	0.11
Initial BW[4], lb	707[a]	689[a]	714[a]	616[b]	19.4	0.10	<0.01	0.01
ADG, lb/d	3.54	3.80	3.63	3.66	0.10	0.77	0.09	0.18
DMI, lb/d	20.1	20.2	20.0	19.2	0.50	0.30	0.42	0.32
F:G, lb:lb	5.75	5.32	5.51	5.29	0.13	0.32	<0.01	0.33
Final BW[5], lb	1352[a]	1381[a]	1374[a]	1281[b]	32.2	0.24	0.23	0.02

[ab] Means within a row lacking a common superscript differ ($P < 0.10$).

[1]Calves entered feedlot 2 wk after weaning.

[2]BRD = breeding treatment main effect; GRZ = grazing treatment main effect; B × G = breeding x grazing treatment interaction.

[3]Calf BW at arrival to the West Central Research and Extension Center.

[4]Calf weight at GrowSafe entry.

[5]A common dressing percent of 63% was used to calculate final BW from HCW.

Table 3. Effect of artificial insemination (AI) or natural service (NS) breeding and upland range (RNG) or sub-irrigated meadow (MDW) grazing on carcass performance of calf-feds[1]

	TREATMENT					*P*-value[2]		
	AI-MDW	AI-RNG	NS-MDW	NS-RNG	SEM	BRD	GRZ	B × G
HCW, lb	851[a]	870[a]	865[a]	807[b]	20.3	0.24	0.23	0.02
Backfat, in	0.58	0.54	0.61	0.48	0.04	0.66	0.02	0.18
Marbling[3]	535	556	524	485	25.6	0.12	0.66	0.14
USDA yield grade	2.86[a]	2.91[a]	3.03[a]	2.48[b]	0.17	0.46	0.07	0.03
LMA[4], in	14.8	14.5	14.5	13.9	0.50	0.37	0.26	0.70
Choice$^-$ or greater, %	88	100	97	83	10	0.98	0.98	0.98
Choice^0 or greater, %	53[ab]	72[a]	50[ab]	30[b]	12	0.10	0.97	0.08

[abc] Means within a row lacking a common superscript differ ($P < 0.10$).

[1]Calves entered feedlot 2 wk after weaning.

[2]BRD = breeding treatment main effect; GRZ = grazing treatment main effect; B × G = breeding × grazing treatment interaction.

[3]Marbling: Small^{50} = 450, Modest^{00} = 500, Modest^{50} = 550.

[4]LMA = *Longissimus* muscle area.

traits reported similar calf BW at birth in March and pre-breeding in May from dams that grazed MDW after parturition until July 20 (*2018 Nebraska Beef Cattle Report*, pp. 15–17); however, numerical differences for calf BW at weaning in November were 62 lb greater in the current study. The WW difference in the current study could be attributed to the duration of the grazing period or the genetic potential of the sires utilized in each individual study.

Post-Weaning Calf Performance

Calf-fed feedlot performance is reported in Table 2. Grazing treatment influenced calf weight ($P < 0.01$) when calves were received at WCREC with MDW calves having greater BW then RNG calves. A breeding × grazing treatment interaction was observed when the calves entered the GrowSafe System with NS-RNG calves having lighter BW than all other treatment groups. Treatment influenced ADG during the feeding period with RNG calves having greater ADG compared with MDW calves ($P = 0.09$). Dry matter intakes were not influenced by breeding or grazing treatments. Grazing treatment influenced F:G with RNG calves having improved feed conversion compared with MDW calves. The observed improvement in ADG and F:G ratios within the RNG calves during the feeding period may be due to a compensatory gain. A breeding × grazing treatment interaction was observed for final live weights with NS-RNG calves having the lightest final live weights; all other treatment groups were similar.

Adjusted carcass performance is reported in Table 3 and contains both steer and heifer data. *Longissimus* muscle area was similar among all treatments ($P \geq 0.26$). A breeding × grazing treatment interaction was observed for HCW and YG ($P \leq 0.03$). Grazing treatment prior to feedlot entry influenced BF with MDW calves having more BF than RNG calves ($P = 0.02$). Marbling scores were similar

for all treatment groups. The percentage of carcasses that graded choice or greater did not differ among treatments. There was a breeding × grazing treatment interaction ($P < 0.08$) for the percent of carcasses grading upper two-thirds choice with the AI-RNG calves having the most, intermediate for the NS-MDW and AI-MDW, and NS-RNG had the least amount of carcasses grading upper two-thirds choice.

Conclusion

Differences in forage quality between native upland range and sub-irrigated meadow did not seem to influence the growth of the AI sired calves during the grazing treatment. Differences observed within the NS breeding treatment may be due to differences in genetic potential of the sires, or the forage quality available during the grazing season. Because the AI sire had a higher terminal index compared with the bulls selected for NS, it was expected the AI sire progeny would have increased growth and performance; however, the progeny in the NS-MDW treatment group had similar growth and performance when compared with the AI sire's progeny. It is likely that larger differences in calf growth and performance would have been observed if there had been a larger difference in the genetic potential of the sires. Additional days on feed may have increased final live weights, BF thickness, and YG of the NS-RNG calves. An economic evaluation of the current study may clarify advantages and disadvantages.

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Economics of Yearling Systems

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Summary with Implications

Economic analyses were conducted to estimate the effect of management decisions on profitability of yearling production systems. Three reported experiments were analyzed where rate of winter gain and length of summer grazing were variables. Corn stalk grazing with distillers grains supplement is quite economical. Winter gains of 1.5 to 2.0 lb/day were more profitable, after grass or after feedlot, than winter gains less than 1 lb/day. Yearlings compensated for lower winter gains while on grass, but those gaining more in the winter gained better in the feedlot and produced heavier final weights. The analyses do not show a clear benefit for marketing yearlings off grass in July versus September.

Introduction

Backgrounding calves/yearlings is much more diverse than producing calves from cows or finishing cattle. Cows primarily graze and are supplemented so they reproduce and wean good calves. Finishing cattle are fed high energy diets to produce high quality beef in an efficient manner. Backgrounding is in between the cow/calf phase and the finishing phase and is partially used to supply cattle to feedyards at various times during the year. This backgrounding can be done in many ways. What are the most economical feed resources? How much should they gain? How much compensatory gain will they make? What is the target market? How does the market respond to weight and body condition? There are many years of research on backgrounding calves/yearlings. The objective was to apply current economics to some of those studies to help the thought processes about some of the previously listed questions.

Procedure

This analysis is not intended to directly predict profit or loss. Instead, it is intended to predict the economic effects of the biological responses to management decisions.

Economic analyses were conducted on three studies previously presented in Nebraska Beef Cattle Reports (*1996 Nebraska Beef Cattle Report*, pp. 51–53; *2005 Nebraska Beef Cattle Report*, pp. 66–67; *2014 Nebraska Beef Cattle Report*, pp. 36–38). All of these studies used cornstalk grazing as part of the wintering period and all yearlings grazed warm or cool season pastures during the summer period. Research (*2009 Nebraska Beef Cattle Report*, pp. 43–46; *2012 Nebraska Beef Cattle Report*, pp. 112–114; *2014 Nebraska Beef Cattle Report*, pp. 36–38), shows that calves can be wintered on cornstalks supplemented with distillers grains up to the time when pasture is available. Grazing until mid-April has actually had positive effects on the corn field (*2015 Nebraska Beef Cattle Report*, pp. 53–55; *2017 Nebraska Beef Cattle Report*, pp. 50–52). Therefore, for this economic analysis, it was assumed the calves were wintered on cornstalks. A cornstalk grazing spreadsheet has been developed that accounts for costs associated with fencing, feeding, etc., for cattle on cornstalks and based on that, $0.56/day is charged for cornstalk grazing. Water was assumed to be available at the cornstalk fields and was not hauled. Supplementation level of distillers grains was varied to provide gains equivalent to those in the 3 studies and the cost added to the cornstalk grazing cost. The distillers grains was priced at 120% the price of corn ($3.50/bu), assuming a greater cost for a backgrounding operation than a feedyard. The yearlings grazed various numbers of days on cool and warm season grasses. Grazing was charged at $0.90/day plus $0.10/day yardage. Wintering and summer grazing were considered a system and marketing after winter grazing was only considered in one analysis.

In two of the three studies, the cattle were finished in the Eastern Nebraska Research and Extension Center (ENREC) feedyard and care was taken to market the cattle as close to equal degrees of finish as possible. The feedyard diet was priced equal to corn price ($3.50/bu) and yardage was priced at $0.50/day.

In all phases of production, interest was charged at 5.6% on the cattle and 5.6% for one half the feed cost. Death loss was assumed to be 1% during receiving and wintering, 0.5% during summer grazing and 0.25% in the feedyard. Cattle market prices were the average of 2017 and 2018 [LMICWeekly & Monthly Combined Nebraska Auction Cattle Prices. Update date January 28, 2019. Livestock Marketing Information Center. Lakewood, CO.]

Results

Morris et al. (*1996 Nebraska Beef Cattle Report*, pp. 51–53) wintered calves at 2 rates of gain (slow and fast; 0.79 or 2.04 lb/d), and then allowed the yearlings to graze grass in the summer for a full season (long) or the first half of the season (short). As expected, grass gains were greater for calves fed slow in the winter (compensatory gain) and for yearlings grazing only during the first 62 days (Table 1). Overall, grass gain the first 62 days was 1.95 lb/d and for the last 58 days was 1.13 lb/d. The net profit for the yearlings off grass was greater for those wintered at a faster rate of gain and may be better for those sold off grass after 62 days if wintered at the fast rate. This is primarily because of the price slide and lighter weight after 62 days of grazing because cost of gain and Grass BE for these calves was actually greater.

Folmer et al. (*2005 Nebraska Beef Cattle Report*, pp. 66–67) compared a "normal" system to an intensive system. In the normal system, the calves were managed

Table 1. Rate of winter gain and length of grazing reported in *1996 Nebraska Beef Cattle Report*, pp. 51–53

	Slow[1] Short[3]	Slow[1] Long[4]	Fast[2] Short[3]	Fast[2] Long[4]
Winter Performance				
Winter gain, lb/d[5,6]	0.79	0.79	2.04	2.04
Winter BW, lb	627	627	785	785
Winter COG[7], $/cwt	133.18	133.08	79.21	79.21
Winter BE[7], $/cwt	177.66	177.66	149.56	149.56
Grass Performance				
Grass gain, lb/d	2.45	2.01	1.44	1.29
Grass BW, lb	779	866	867	938
Grass COG[7], $/cwt	72.40	74.58	125.15	117.41
Winter Plus Grass BE, $/cwt[8]	157.06	149.22	148.04	144.31
Market, $/cwt	164.17	155.50	156.05	150.73
System Net Profit, $/hd	55.40	54.43	69.46	60.21

[1]2 lb distillers grains daily (DM)

[2]5 lb distillers grains daily (DM)

[3]Short-62 days of summer grass grazing

[4]Long-120 days of summer grass grazing

[5]Purchase wt-500 lb

[6]127 d grazing cornstalks

[7]COG is cost of gain

[8]Breakeven (BE) is for the total system including winter

Table 2. Normal and intensive backgrounding systems reported in *2005 Nebraska Beef Cattle Report*, pp. 66–67

	Normal[1]	Intensive[2]
Winter Performance		
Winter gain, lb/d	1.66	1.96
Winter BW, lb	803	850
Winter COG[3], $/cwt	83.05	78.81
Winter BE[3], $/cwt	151.39	145.96
Grass Performance		
Grass gain, lb/d	1.72	1.98
Grass BW, lb	1023	1004
Grass COG[3], $/cwt	86.45	84.67
Grass BE[3], $/cwt	137.41	136.55
Market, $/cwt	146.06	146.57
Winter plus Grass Net Profit, $/hd[4]	88.45	100.57
Feedlot Performance		
Feedlot gain, lb/d	4.27	3.96
End BW, lb	1449	1447
Feedlot COG[3], $/cwt	74.81	75.34
Feedlot Net Profit, $/hd	-15.60	-89.87
System BE[3], $/cwt	118.17	117.80
Market, $/cwt	123.33	118.67
System Net Profit, $/hd[5]	74.81	12.59

[1]Normal-moderate winter gain (4.8 lb DM distillers grains supplemented daily) and full season summer grass grazing (128 d)

[2]Intensive- greater winter gain (6 lb DM distillers grains supplemented daily) and 78 days summer grass grazing

[3]COG is cost of gain and BE is breakeven

[4]Net includes the winter phase

[5]Net income for complete system

to gain 1.66 lb/d in the winter and then as yearlings grazed grass for the entire summer grazing season. In the intensive system, the calves were managed to gain 1.96 lb/d in the winter and then as yearlings allowed to graze grass for only 78 days. The goal was to produce yearlings of comparable weight off grass in the two systems. When fed in the feedyard, the yearlings in the intensive system were marketed in November, and those in the normal system, in January.

The net profit off grass was about $12 greater ($100.57 vs. $88.45) for the yearlings in the intensive system (Table 2). Thus if selling after the grass phase the intensive system was more favorable. However, the market for finished cattle was nearly $5/cwt greater in January (normal system) than November (intensive system). This caused the finished system net profit to be much greater ($62 per animal) for the cattle off grass in September in the normal system than in the intensive system. The 10-year average is $3.66/cwt higher price for fat cattle in January than November.

Gillespie et al. (*2014 Nebraska Beef Cattle Report*, pp. 36–38), summarized six studies that compared the effect of winter rates of gain on overall growing-finishing system. The low winter gain was achieved with 2 lb (dry matter) of distillers grains on cornstalks and the high winter gain was 5 lb distillers grains. Profit after wintering on cornstalks was greater for calves wintered at the higher rate. Net profit off grass was greater ($54.09 vs. $42.34) for the yearlings that had gained at a higher rate over the winter (Table 3). Profit was greater for the winter phase for calves wintered at the higher rate of gain. Profit for the grass phase was greater for those wintered at the lower rate of gain. While the yearlings compensated on grass for lower winter gains, the yearlings that had higher winter gains and lower grass gains appeared to compensate in the feedyard. Those wintered at 1.4 lb/d had heavier carcasses and much greater system net profit when finished.

This summary of 6 studies covering 7 years is good because of the numbers of years, cattle, and environmental conditions included. The limitation is the relatively low pasture gains. During 2 of the years, steers gained more (1.95 and 1.32 lb/d on grass, low and high winter gain respectively) than the averages used in this economic analysis. However, the outcomes for the economic

analysis when using these greater summer grains were similar to those for the 6 study average with somewhat greater profit responses for those steers wintered at the higher rate of gain.

Generalizations will be made from these analyses. First, the availability of distillers grains has a large impact on the nutrition and economics of backgrounding cattle. Other than grazed cornstalks, it is often the least expensive source of energy and is an excellent source of bypass protein (RUP) to supply needed metabolizable protein. Producers cannot supply rumen degradable protein and expect similar results. Second, winter gains should likely be targeted at 1.5 to 2.0 lb/d. All of the studies indicated that the net effect of more rapid winter gains was positive even though the yearlings made compensatory gain on grass when wintered at lower rates of gain. The overall performance and final weights seem to be more important than grass gains. Third, while daily gains on warm season grasses decline as the season progresses, from these studies, it does not seem to be especially advantageous to sell yearlings off grass in July versus September. The perception is that the yearling price off grass in July is greater than that in September. The 2017 and 2018 price for 950–1000 lb yearlings was not different for yearlings in July vs. September. The 10-year average was $2.45/cwt greater in July than September, but this was due to higher July prices in 2015 and 2016 and the other years the September price was similar to the July price. In the study reported in the *1996 Nebraska Beef Cattle Report*, pp. 51–53, the yearlings were 79 lbs heavier in September than July. Because of the price slide, the price for 79 lb lighter yearlings would be higher in July. The income was $67.20 higher for the yearlings in September and the cost of grazing would make the net similar, thus it is not clear that selling cattle off grass in July is more profitable than selling later in the season. If the yearlings are retained through the feedyard, it is advantageous to leave them on grass until September because of higher finished prices in January. Admittedly, there can be weather risks in December and January. Gains on cool season grasses may respond with later season grazing because of late summer, early fall regrowth, which would seem to be even more advantageous for allowing grazing into September or October.

Table 3. Effect of rate of winter gain in backgrounding systems reported in *2014 Nebraska Beef Cattle Report*, pp. 36–38

	LO[1]	HI[2]
Winter Performance		
Winter gain, lb/d	0.57	1.40
Winter BW, lb	610	741
Winter COG[3], $/cwt	176.73	101.48
Winter BE[3], $/cwt	166.32	143.69
Market, $/cwt.	165.78	147.86
Net Profit, $/hd	-3.29	30.90
Grazing Performance		
Grass gain, lb/d	1.39	1.06
Grass BW, lb	819	900
Grass COG[3], $/cwt	101.27	133.65
Grass BE[3], $/cwt	149.76	141.92
Market, $/cwt	154.93	147.93
Grass Net Profit, $/hd[4]	42.34	54.09
Grass Net Profit, $/hd[5]	45.63	23.19
Feedlot Performance		
Feedlot gain, lb/d	4.0	4.18
End BW, lb	1275	1360
Feedlot COG, $/cwt	74.56	72.82
Feedlot Net Profit, $/hd	-41.71	7.52
System BE, $/cwt	122.86	118.55
Market, $/cwt	123.33	123.33
System Net Profit, $/hd[6]	5.99	65.01

[1] 2 lb distillers grains (DM) daily while grazing cornstalks

[2] 5 lb distillers grains (DM) daily while grazing cornstalks

[3]COG is cost of gain and BE is breakeven

[4]Net income including winter phase

[5]Profit for only grass phase

[6]Net income for complete system

While cornstalk grazing is an economical system for wintering calves, alternative systems may fit some operations. Table 4 shows a comparison of wintering methods. The estimate for cornstalk grazing to obtain 1.66 lb/d gain is $0.95/d cost of feed and yardage. In the Sandhills where cornstalks are not readily available, winter range priced at one-half of summer range rates would give a cost of $1.12/d. In a system where hay is fed on a pasture and calves are supplemented with distillers grains to achieve the same gain, the cost is estimated at $1.05/d. Costs for two systems of backgrounding in a feedyard are estimated. Corn silage supplemented with distillers grains costs $1.29/day and high levels of distillers grains with straw or cornstalks would cost about $1.34/d to achieve the same gains as the calves on cornstalks. The extensive systems of stalk grazing, winter range, or hay feeding, appear more economical than the feedlot systems. Over the wintering period, the 4 alternative systems (winter range, grass hay, corn silage in the feedlot, straw cornstalks/distillers in the feedlot) would increase costs $25, $15, $51, and $59 compared to cornstalk grazing for 150 days.

Cornstalk grazing may be more variable and present more weather risks than other systems. Some producers have experienced lesser cornstalk grazing gains than those measured in the UNL research program over 35 years. Recently, Welchons et al. (*2018 Nebraska Beef Cattle Report*, pp. 40–44), measured 1.8 lb/d daily gain over 2 years on cornstalks with 5.5 lb (DM) of

Table 4. Comparison of methods of wintering calves

Scenario	Feeds and Yardage	Amount[1], lb/d	Cost, $/d	Total Cost, $/d
Grazing cornstalks	Cornstalks		0.56	
	Distillers grains	4.8	0.39	0.95
Winter range	Grass		0.45	
	Distillers grains	5.8	0.47	
	Yardage		0.20	1.12
Grass hay [2]	Grass hay	13	0.64	
	Distillers grains	2	0.16	
	Yardage		0.25	1.05
Feedlot limit fed	Corn silage	11	0.58	
	Distillers grains	2.8	0.21	
	Yardage		0.50	1.29
Feedlot limit fed	Straw/cornstalks[3]	5.5	0.22	
	Distillers grains	8.3	0.62	
	Yardage		0.50	1.34

[1] Dry matter basis

[2] Fed in round bale feeder or unrolled on the ground ($80/ton).

[3] Blend of 60% distillers grains and 40% straw or cornstalks.

distillers grains provided daily. In the 1980s, measurements indicated about 4.2% down corn left in the field while in recent years that has been 0.5% to 1%. As indicated above, cattle still maintain good performance on cornstalks even with less down corn to consume. Weighing conditions are important and in commercial production, calves may be weighed with minimal fill. Watson et al. (*2012 Nebraska Beef Cattle Report*, pp. 45–46) reported that when calves were driven in the morning 1 mile, and weighed, they were 27.5 lb. lighter than when weighed 3 days later after being limit fed a diet in the feedlot and weighed before feeding in the morning. Over the last 8 years, 7493 UNL calves have been wintered on rented cornstalks near ENREC in groups of several hundred, much like a commercial operation. Initial weights were off the truck at receiving and the calves were received on pasture for 3 to 4 weeks before going to cornstalks. End weights were after a couple miles drive from cornstalk fields. Calves were supplemented with 5 lb. (dry matter) of Sweet Bran daily. Calves grazed an average of 105 days and daily gains from receiving through cornstalk grazing averaged 1.45 lb/day. Stocking rate, system of supplement feeding, amount of supplement fed, field rotation and weather are all factors influencing gains on stalks.

Conclusions

Backgrounding is an important segment of the beef production system. Cornstalk grazing and distillers grains are economical resources for wintering calves. Rates of gain for the winter should be above 1.5 lb/d to provide most economical production of finished cattle or yearlings sold off grass.

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Forage Production and Calf Gains When Grazing Oats following Corn Harvest

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Summary with Implications

A 4 yr. study was conducted to evaluate forage yield and grazing potential of double cropped annual forages following corn silage or high-moisture corn harvest. An irrigated field in a corn-soybean rotation was split in half and harvested as either corn silage or high-moisture corn, and crops were sampled to determine any effects on subsequent yield due to cover and grazing. Over the four years, steers grazing oats after corn silage harvest gained an average of 2.35 lb/d, while those grazing corn residue and oats after high-moisture corn harvest averaged 1.28 lb/d. Average oat forage production after corn silage was 2,208 lb/ac, while due to later planting dates, oat production after high-moisture corn harvest averaged 910 lb/ac. Planting cover crop forages following corn silage harvest provides producers opportunities for additional body weight gain with greater forage production than planting after high-moisture corn, with no apparent impacts on subsequent yields.

Introduction

Grazing livestock on late-summer planted double-cropped annual forages may provide opportunities for producers to extend their grazing season between summer range and winter residue grazing. Double-cropped annual forages (DCAF), commonly referred to as cover crops have increased in popularity recently. Cover crops provide numerous agronomic advantages for land owners, including, soil conservation, weed control, and economic incentives (grazing rent). Additionally, late-summer planted cover crops may provide animal gains and economic benefits for livestock producers and land owners. Corn harvest timing affects the amount of fall forage produced, due to limited growing degree days (GDD). Early harvested corn, such as corn silage (CS) results in more GDD available for fall forage production compared to high-moisture corn (HMC) harvest, where forage production is used as a supplement to corn residue. Therefore, the objective of this study was to determine calf gains and forage production of oats following corn silage or high-moisture corn harvest, as well as their impact on subsequent crop yields.

Procedure

Field and Planting Details

In a 4 yr study, a pivot irrigated field located at the Eastern Nebraska Research and Extension Center (ENREC) near Mead, NE was utilized to determine oat forage production and calf gains following CS and HMC harvest, as well as their effects on subsequent crop yield. The 104-acre field was split into a corn and soybean rotation (52-ac each). Corn and soybeans were planted with 7.5-in row spacing. The half of the field planted to corn was split again into CS (26-ac) and HMC (26-ac). Each year, corn was harvested as either CS (September 1st) or HMC (September 15th), and double-cropped with an oat monoculture, and grazed according to treatment. Horsepower oats were drilled at 90 lb/ac following CS and HMC harvest, and a 32% ammonium nitrate fertilizer was applied at a rate of 40 lb/ac. In 2018, due to limited emergence of the oats planted on the CS, Horsepower oats were re-planted on the CS at 90 lb/ac on the day that oats were planted on the HMC. Treatments included double crop annual forage (DCAF) followed by grazing (Cov-G), DCAF without grazing (Cov-NG), and no DCAF (NC-NG). Treatments were initially applied in 2013; however, due to herbicide restrictions, no grazing occurred until 2015.

Forage Production Measures

Initial oat biomass was sampled in late October to determine forage production, and to determine stocking rates. Total biomass was measured by randomly selecting (36 x 22.5 in) areas within each treatment paddock that contained cover (CS Cov-G, CS Cov-NG, HMC Cov-G, and Cov-NG). Forage was clipped at ground level, bagged, and dried for 48 h in a 60°C oven to determine initial biomass. Furthermore, corn stover was sampled on the HMC side to account for the total amount of residue removed due to grazing. Growing degree days were calculated for each treatment to account for differences in planting date.

During initial biomass sampling, forage quality samples were taken for each treatment (2 rep/treatment) containing oats. Samples were taken by randomly clipping oats at ground level uniformly across each paddock. Samples were dried at 100°C for 24 h to determine DM and analyzed for OM, CP, NDF, and ADF.

After the grazing period, forage biomass was sampled the same as initial biomass, and transects were taken to determine percent cover. Transects were taken using a 100 ft tape stretched randomly across areas within each treatment. At each 1 ft., it was determined whether the soil was covered or not, these were then averaged to determine a percentage of cover at each area.

Crop Yield

Corn silage, high-moisture corn, and soybean yields were collected to determine subsequent crop yields following the previous years imposed treatments. Hand harvest of corn included cutting the corn plant at the first node for 17.5 ft at 9 locations/treatment. Corn ears were removed, and the ear and remaining plant stover (husk, leaf, and stalk) were weighed separately. For CS the remainder of the corn plant was ground

Table 1. 4 yr. averages of calf performance grazing oats seeded after corn silage or high-moisture corn harvest, forage production, growing degree days, and soil cover

	Treatment			
Item	CS[1]	HMC[2]	SEM	*P*-value
Calf Performance				
Initial BW, lb	491	488	14.3	0.53
Ending BW, lb	592	541	17.2	0.02
ADG, lb	2.35	1.28	0.381	0.01
Gain, lb / ac	244	143	66.7	0.04
Oats Forage Production				
Biomass, lb / ac[3]	2208	910	155.7	<0.01
GDD[4]	649	354	36.0	<0.01
Post graze cover, %[5]	66.8	86.6	3.60	<0.01

[1]Calf performance and forage production of oats seeded after corn silage harvest

[2]Calf performance and forage production of oats seeded after high-moisture corn harvest

[3]Biomass determined prior to the grazing period

[4]GDD (growing degree days of oats) = [maximum temperature (°C)—minimum temperature (°C) (if min. temp. < 0, then set = 0] summed from d oats seeded to d initial oat biomass sampled.

[5]Percent cover determined by transects after the grazing period. Treatment averages.

through a chipper, weighed wet, subsampled, and dried to determine yield.

Soybean plants were hand harvested at ground level. Samples were then bundled, and dried in a drying room at 60°C until threshing. During threshing, grain and stover were collected, weighed wet, and dried. Dry matter oven weights for the grain and stover were used to calculate soybean grain and stover yield per acre.

Cattle Grazing and Management

Sixty-two steer calves (initial BW = 467 lb; SD = 20 lb) were utilized in 2015, fifty-five (initial BW = 503 lb; SD = 29 lb) in 2016, thirty-four (initial BW = 463 lb; SD = 29 lb) in 2017, and thirty-six steer calves (initial BW = 507 lb; SD = 7 lb) were utilized in 2018 for oat grazing. Prior to grazing, steers were limit fed a common diet of 50% Sweet Bran (Cargill Wet Milling, Blair, NE) and 50% alfalfa hay for 5 d, then weighed for 3 consecutive d to establish initial BW. Cattle were stratified by BW and assigned randomly to paddocks with two paddocks in each the CS and HMC treatments. Due to differences in available forage, number of head varied between paddocks. Therefore, a set number of head were determined to be testers within each treatment paddock. In 2015, and 2016 10 hd/paddock were assigned as testers, while only 5 hd/paddock were assigned as testers in 2017 and 2018. Grazing performance was determined based upon the tester performance averaged over all calves in the treatment paddock.

Calves were implanted with 36 mg Zeranol (Ralgro, Merck Animal Health, Madison, NJ) and turned out into their respective paddocks in early November.. Stocking rates were calculated using a predetermined 70 d grazing period, with a 60% grazing efficiency, intakes estimated at 2.5% of BW, and initial biomass measurements of lb DM / ac within each grazing paddock. Stocking rates ranged from 0.65 to 1.66 hd/ac on the CS and 0.92 to 1.32 hd/ac on the HMC treatment. In 2015–2017 treatments were grazed until forage availability was determined to be limiting intake, whereas weather in 2018 resulted in termination of grazing (62, 42, 48, and 30 days; respectively over the four years). Upon removal from the grazing treatments, steers were limit fed the same 50:50 alfalfa and Sweet Bran diet for 8 d and were weighed for 3 consecutive d to limit differences in gut fill and determine ending BW.

Data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.). Paddock was the experimental unit for calf performance and oat forage quality data. Treatment was analyzed as a fixed effect for steer performance, and subsequent corn and soybean yields. Treatment means were separated using the pdiff statement when the F-test was significant. Data were considered to be significantly different at $P \leq 0.05$.

Results

Forage Production and Quality

Oat forage biomass production was greater following CS than HMC with 2,208 lb DM / ac compared to 910 lb DM / ac, respectively ($P < 0.01$, Table 1). Corn stover from the HMC provided 1,669 lb DM / ac making total lb DM / ac between the treatments similar. Although, due to limited oat emergence on the CS in 2018, HMC oat biomass was more similar to CS than in previous years (1,531 vs. 1,952 lb/ac, respectively). Furthermore, GDD were calculated to estimate the number of possible days of oat forage growth from the time of planting to initial biomass measurements, based on average daily temperature. Average GDD were significantly different for the two treatments, with oats planted on CS averaging 649 d and HMC averaging 354 d, respectively ($P <0.01$). Significantly greater forage production following CS is likely due to the difference in average GDD between the treatments and cover from the HMC residue. Due to HMC residue, percentage ground cover, estimated using transects, was significantly different between CS and HMC (66.8% and 86.6% respectively; $P < 0.01$). However, planting of oat forage on the CS side provided improved soil cover regardless of grazing treatment, resulting in more similar cover provided by the corn residue remaining on the HMC side, compared to the NC-NG CS treatment.

Nutrient quality of oats (OM, CP, NDF, and ADF) is reported in Table 2. Oat OM was not different ($P = 0.38$) whether it was planted following CS or HMC harvest (86.7% and 87.0%, respectively). Nonetheless, CP was greater in the oats seeded following HMC compared to CS at 22.7 and 18.0%, respectively ($P < 0.01$). Oats planted following HMC harvest were less mature than those following CS, likely contributing to the increase in CP content. There was a tendency ($P = 0.09$) for oats planted after CS to have greater NDF compared to HMC (38.3% and 35.9% respectively). Furthermore, ADF was greater for oats following CS compared to HMC (24.0 vs. 21.9, respectively; $P < 0.01$). Nonetheless, oats

planted after CS or HMC harvest resulted in a high quality forage for grazing.

Calf Performance

Calf initial and ending BW, average daily gain (ADG), and gain per acre is reported in Table 1. Steers grazing oats following CS had greater ending BW than those grazing after HMC (592 and 541 respectively; P = 0.02). Accordingly, calves grazing the CS treatment had greater ADG than steers grazing the HMC treatment (P = 0.01) with an ADG of 2.35 and 1.28 lb/d, respectively and gain per acre was greater for the CS treatment than the HMC treatment (244 lb/ac and 143 lb/ac respectively; P = 0.04). Calf gains differed between the two treatments due to greater oat production on the CS treatment. Additionally, calves grazing the HMC treatment consumed the oats prior to the corn residue, thus, planting oats after HMC harvest may not be an effective supplementation strategy when grazing.

Crop Yields

An interaction was observed between corn treatment and DCAF treatment for subsequent soybean yields (P = 0.01; Figure 1). The interaction suggests that when soybeans were planted after HMC, the oats with or without grazing had no impact on subsequent soybean yield. However, when soybeans followed CS, oats without grazing reduced yields, compared to oats with grazing and no oats with no grazing. Regardless of the corn treatment, grazing DCAF did not appear to impact subsequent soybean yields. Corn yields were compared across treatments for 2017 and 2018, to evaluate the impact of grazing in 2015 and 2016 respectively. Corn silage yields, HMC grain, and HMC stover yields were not different among treatments ($P \geq 0.10$; Table 3).

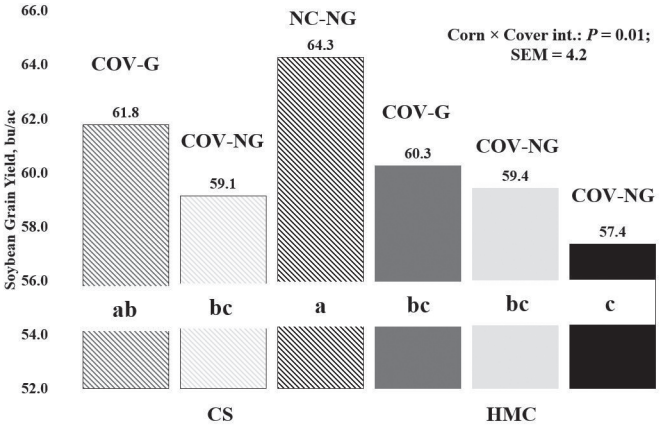

Figure 1. 4yr. Averages for subsequent soybean yields (bu/ac) following oat forage with and without grazing

Table 2. 4 yr. averages for forage quality of oats planted after corn silage and high-moisture corn harvest

	Treatment			
Item[1]	CS[2]	HMC[3]	SEM	*P*-value
OM	86.7	87.0	0.01	0.38
CP	18.0	22.7	0.91	<0.01
NDF	38.3	35.9	0.02	0.09
ADF	24.0	21.9	0.01	<0.01

[1]All treatment means are percentages

[2]Nutrient content of oats seeded after corn silage harvest

[3]Nutrient content of oats seeded after high-moisture corn harvest

Table 3. 4 yr. averages for subsequent corn yields following oat forage with and without grazing[1]

	Treatment[2]				
Item	Cov-G	Cov-NG	NC-NG	SEM	*P*-value
Corn Silage Yield, ton/ac	8.6	7.3	8.8	0.49	0.10
HMC Grain Yield, bu/ac	222	210	203	1.3	0.48
HMC Stover Yield, ton/ac	4.1	4.0	3.6	0.19	0.21

[1]Average corn silage and high-moisture corn yields from 2017, and 2018 following oats planted after corn silage or high-moisture corn harvest, in 2016 and 2017

[2]Cov-G = grazed oats, Cov-NG = ungrazed oats, NC-NG = ungrazed without oats drilled

Conclusion

Grazing double-cropped oats following corn harvest provides producers an opportunity to add additional weight to weaned calves, and may offer an economic incentive to cropping systems with no impact on subsequent crop yields. Due to fewer GDD, substantially less forage production is observed following HMC harvest, leading to less desirable gains compared to oats planted after CS. Seeding and grazing of oat forage following CS offers numerous benefits for livestock and crop producers.

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Evaluation of Rup Content of Nexpro Dried Distillers Grains plus Solubles and Their Effect on Growing Calf Performance in Corn Silage Based Diets

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Summary with Implications

A growing study was conducted to evaluate the effect of supplementing NexPro, a high-protein dried distillers grains plus solubles (DDGS) from the FluidQuip MSC post-fermentation separation process, in a corn-silage based diet and to determine the rumen undegradable protein (RUP) content of NexPro. Three test proteins (NexPro, SoyPass, and soybean meal) and 4 inclusion levels (4.5, 9, 13.5, and 18%) were evaluated against a common control (0% test protein). There were no differences in dry matter intake among treatments. Increasing inclusion of NexPro resulted in improved feed conversion and daily gain. SoyPass and soybean meal supplementation also resulted in improved daily gain and feed conversion. Providing additional protein, and specifically rumen undegradable protein, improves cattle performance when fed corn silage growing diets. Performance of steers fed NexPro and SoyPass were similar, which supports NexPro having a similar RUP content.

Introduction

Utilization of corn silage allows cattle feeders to harvest the entire corn plant and provide a high quality, yet affordable forage. Corn silage ranges from 6.5 to 8.5% crude protein (CP) with less than 10% of the CP being digestible RUP (2018 Nebraska Beef Report, pp. 52–54). Because of corn silage's low rumen undegradable protein (RUP) content and relatively high energy, supplementation of distillers grains plus solubles (DDGS) will improve calf performance. A new distillers processing technique (Flint Hills Resources, Wichita, KS) is producing high-protein DDGS, termed NexPro, with a crude protein content of 52% (dry matter [DM] basis). Traditional DDGS range from 30–34% crude protein with 63% of that being RUP. Therefore, our objective was to determine the effects of supplementing NexPro in corn silage-based diets on growing calf performance, and the RUP content of NexPro based on performance by comparison to SoyPass and conventional soybean meal, which are similar in CP to NexPro.

Procedure

An 84 d growing study was conducted at the University of Nebraska feedlot near Mead, NE using 120 crossbred steers (initial BW = 551 ± 53 lb). All steers were individually fed using the Calan gate system. Steers were limit fed a diet consisting of 50% alfalfa hay and 50% Sweet Bran for five days prior to trial initiation at 2% of BW to reduce gut fill variation. Steers were weighed 3 consecutive days (d -3, d -2, and d -1) to establish average initial BW. Steers were stratified by d -3 and d -2 BW and assigned randomly to one of 13 treatments. Treatments were arranged in a 3 × 4 + 1 factorial with test protein (NexPro, SoyPass, soybean meal) and inclusion (4.5%, 9.0%, 13.5%, 18.0% of diet DM) being the factors, plus a shared control with 0% test protein. Steers were implanted on d -1 with Ralgro and fed ad-libitum once daily. Feed refusals were collected weekly, weighed, and dried in a 60° C forced air oven for 48 hours to calculate accurate DMI for individual steers. At conclusion of the study, steers were offered the same limit fed diet at 2% of BW for 5 days to minimize variation in gut fill. Ending BW was calculated as the average of weights collected on 3 consecutive days after the conclusion of the limit feeding period. Treatment diets are presented in Table 1. The diets consisted of 80% corn silage with the remaining 20% being fed as either RDP or test protein supplement. Both supplements contained minerals, vitamins A-D-E and a finely-ground corn carrier. Test proteins were used to provide supplemental RUP and included NexPro (51.4% CP, 50% RUP as % of CP), SoyPass (48.8% CP, 74% RUP as % of CP) as a positive control, and conventional soybean meal (52.4% CP, 22% RUP as % of CP) as a negative control. Samples of test proteins utilized in the cattle performance study were analyzed for CP and RUP content using an *in situ* process. SoyPass is a non-enzymatically browned soybean meal. Four levels of supplementation were evaluated with 8 steers per inclusion of test protein with a common control represented by 24 steers.

Data were analyzed using the GLIMMIX procedure of SAS as a randomized design. Steer was the experimental unit. Orthogonal contrasts were used to analyze linear and quadratic effects of inclusion of each test protein. Slopes of the response to inclusion of test protein were determined using the regression procedure of SAS and slopes were compared using the GLM procedure of SAS. Treatment means were compared when the F-test statistic for treatment was significant. Significance was declared at $P \leq 0.05$ and tendencies at $P \leq 0.10$.

Results

Performance results for NexPro, SoyPass, and soybean meal are presented in Tables 2, 3 and 4, respectively. There were no interactions observed for DMI (dry matter intake), ADG (average daily gain), or feed conversion among type of protein supplementation and inclusion level ($P \geq 0.29$). There were no differences in DMI ($P \geq 0.15$) among treatments. Steers supplemented with NexPro had a quadratic ($P = 0.01$) increase in ADG. NexPro steers had a linear ($P < 0.01$) improvement in F:G. SoyPass supplemented steers had a linear ($P < 0.01$) increase in ADG and a linear ($P < 0.01$) improvement in F:G. Supplementation of soybean meal resulted in a quadratic ($P =$

Table 1. Diet composition (% of diet DM) of growing diets individually fed to steers for 84 d

	Treatment[1]				
Ingredient, %	0.0%	4.5%	9.0%	13.5%	18.0%
Corn Silage	80.0	80.0	80.0	80.0	80.0
RDP Supplement[2]	20.0	15.0	10.0	5.0	-
Test Protein Supplement[3]	-	5.0	10.0	15.0	20.0

[1] Treatments: Diets contained 80% corn silage and were formulated to contain 0, 4.5, 9.0, 13.5 or 18.0 % test protein. Test Proteins included soybean meal, SoyPass, or NexPro

[2] RDP supplement formulated for a target inclusion of 20% total diet DM and contained 81.45% fine ground corn, 8.55% urea, 5.60% limestone, 2.50% tallow, 1.50% salt, 0.25% trace minerals, 0.075% vitamin A-D-E. Formulated to provided 200 mg/steer daily Rumensin (Elanco Animal Health)

[3] RUP supplement formulated for a target inclusion of 20% total diet DM and contained 90.0% test protein, 5.60% limestone, 2.50% tallow, 1.50% salt, 0.25% trace minerals, 0.075% vitamin A-D-E. Formulated to provide 200 mg/steer daily of Rumensin (Elanco Animal Health)

Table 2. Performance of growing steers fed a corn silage-based diet supplemented NexPro at 0.0, 4.5, 9.0, 13.5, or 18.0% DM inclusion

	Inclusion, %							*P*-values	
	0.0	4.5	9.0	13.5	18.0	SEM	F-test	Lin.	Quad
Performance									
Initial BW, lb	554	548	549	547	559	19.7	0.99	0.85	0.59
Final BW, lb	703^{b}	747^{ab}	741^{ab}	791^{a}	772^{a}	22.1	0.08	<0.01	0.35
DMI, lb/d	15.5	16.6	16.1	17.1	16.6	0.75	0.15	0.19	0.52
ADG, lb	1.78^{c}	2.37^{b}	2.29^{b}	2.91^{a}	2.53^{ab}	0.15	<0.01	<0.01	0.01
Feed:Gain	8.74^{b}	6.94^{a}	7.08^{a}	5.86^{a}	6.49^{a}	-	<0.01	<0.01	0.11

^{a,b,c} means with different superscripts within a row differ (P<0.05). Superscripts can be compared between tables.

Table 3. Performance of growing steers fed a corn silage-based diet supplemented SoyPass at 0.0, 4.5, 9.0, 13.5, or 18.0% DM inclusion

	Inclusion, %							*P*-values	
	0.0	4.5	9.0	13.5	18.0	SEM	F-test	Lin.	Quad
Performance									
Initial BW, lb	554	553	545	544	549	19.7	0.99	0.71	0.80
Final BW, lb	703^{b}	745^{ab}	748^{ab}	743^{ab}	782^{a}	22.1	0.08	0.01	0.86
DMI, lb/d	15.5	17.5	17.8	14.8	16.7	0.75	0.15	0.84	0.18
ADG, lb	1.78^{c}	2.28^{b}	2.42^{ab}	2.36^{b}	2.78^{a}	0.15	<0.01	<0.01	0.45
Feed:Gain	8.74^{b}	7.49^{b}	7.37^{b}	5.94^{a}	5.84^{a}	-	<0.01	<0.01	0.97

^{a,b,c} means with different superscripts within a row differ (P<0.05). Superscripts can be compared between tables.

Table 4. Performance of growing steers fed a corn silage-based diet supplemented soybean meal at 0.0, 4.5, 9.0, 13.5, or 18.0% DM inclusion

	Inclusion, %							P-values	
	0.0	4.5	9.0	13.5	18.0	SEM	F-test	Lin.	Quad
Performance									
Initial BW, lb	554	554	550	544	560	19.7	0.99	0.66	0.66
Final BW, lb	703^{b}	737^{ab}	755^{a}	752^{ab}	758^{a}	22.1	0.08	0.04	0.30
DMI, lb/d	15.5	16.4	17.4	16.3	15.9	0.75	0.15	0.78	0.07
ADG, lb	1.78^{c}	2.18^{b}	2.44^{b}	2.49^{b}	2.36^{b}	0.15	<0.01	<0.01	0.01
Feed:Gain	8.74^{b}	7.45^{ab}	7.10^{a}	6.44^{a}	6.75^{a}	-	<0.01	<0.01	0.21

^{a,b,c} means with different superscripts within a row differ (P<0.05). Superscripts can be compared between tables

0.01) increase in ADG. Steers supplemented with soybean meal also had a linear ($P < 0.01$) improvement in F:G. Using regression analysis there were no differences ($P \geq 0.13$) between SoyPass, NexPro, and Soybean meal slopes as ADG or feed efficiency increased in response to increased inclusion of the test proteins.

Supplementation at the highest inclusion of NexPro showed a 42% increase in ADG over the control while the Soypass supplemented steers showed a 56% increase in ADG. Feed conversion of the NexPro and Soypass supplemented steers improved 26 and 33%, respectively, over the control fed steers. Soybean meal supplementation resulted in improvements to ADG and F:G by 32 and 23%, respectively. Increasing the inclusion of NexPro resulted in a metabolizable protein (MP) balance of -231 to +114 g/d. NexPro included at 9% of the diet had a -60 g/d balance while the MP balance at 13.5% was +24 g/d. This could explain the quadratic response for daily gain with high inclusions of NexPro as daily gains and F:G are similar from 13.5 to 18% inclusion.

Conclusion

Supplementation of protein in corn-silage based diets resulted in increased final BW, ADG, and improved feed conversion. Use of NexPro and SoyPass resulted in greater improvements than the use of soybean meal, confirming that they have a greater RUP content. Performance of steers fed NexPro and SoyPass were similar, which supports NexPro having a similar RUP content.

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Effect of Conventional or High Protein Dry Distillers Grains Plus Solubles in Either Dry-Rolled or Steam-Flaked Corn Based Diets on Amount and Site of Nutrient Digestion

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Summary with Implications

A 2 × 3 factorial metabolism study using 6 ruminally and duodenally cannulated heifers evaluated the site and amount of nutrient digestion when feeding high protein dry distillers grains plus solubles (DDGS) or conventionally produced DDGS at 30% inclusion compared to feeding no distillers in either dry-rolled or steam-flaked corn diets. Apparent total tract starch digestibility was unaffected by distillers treatment in SFC-based diets, but decreased from 95.1% to 92.0% when DDGS was added to DRC diets, and further decreased to 88.7% for HiPro diets. Dry matter and OM digestibilities were lower types of when either DDGS diets were fed, but no differences were observed between conventional or high protein DDGS. Feeding high protein DDGS did not change digestion compared to conventional DDGS, despite higher CP content. Digestion is greater when cattle are fed steam-flaked corn compared to dry-rolled corn.

Introduction

High protein DDGS is the result of fractionation during ethanol production to produce a concentrated protein byproduct. This feed may result in extra benefit for producers feeding DRC-based diets, because the bypass protein fraction of DDGS, when used for energy by the cattle, contributes to the positive performance observed when cattle are fed DDGS (2016 Nebraska Beef Cattle Report, pp. 124–127). Starch digestion can be limited in ruminants due to limited α-amylase production from the pancreas at the entry of the small intestine. There has been some research suggesting increasing protein post ruminally stimulates the pancreas to release more α-amylase, thus enhancing starch digestion and absorption in ruminants, potentially improving performance. Steam flaked corn has more readily available and fermentable starch than DRC, so improvements in starch digestion are more likely to be observed in DRC-based diets. Therefore, the objective of this study was to evaluate feeding high protein (HiPro) DDGS compared to conventionally produced DDGS on starch digestibility throughout the digestive tract in either dry-rolled or steam-flaked corn-based diets.

Procedures

A 2 × 3 factorial metabolism study evaluated the effect of no distillers included in the diet (CON), a diet containing 30% conventionally produced DDGS (DDGS), or diet including 30% high protein DDGS (HiPro) in either dry-rolled (DRC) or steam-flaked (SFC corn diets. Six ruminally and duodenally cannulated beef heifers were utilized in a 6 × 6 Latin square with six treatment periods. Heifers were housed individually in concrete slatted pens with ad libitum access to feed and water. They were assigned randomly to each treatment for six, 21-d periods, each allowing for 14-d of adaptation followed by 7-d of collection. Diets (Table 1) were mixed twice weekly and stored in a cooler (0°C) to ensure fresh feed for animals. Supplement included 30 g/ton DM of Rumensin (Elanco Animal Health) and 8.8 g/ton of Tylan (Elanco Animal Health). Heifers were dosed with 5.0 g/heifer of titanium dioxide inserted through the rumen cannula twice daily at 0800 and 1600 h beginning on d-7 of each period. Fecal and duodenal samples (approximately 300 g each) were collected at 0800, 1200, 1600 and 2000 h from days 17 to 20 of each period. Whole rumen contents and rumen fluid were collected on d-21 for VFA, NH_3, and purine analysis. Fecal samples were composited by day and freeze dried and composited by period, whereas duodenal samples were freeze dried then composited by day then period. Samples were analyzed for neutral detergent fiber (NDF), acid detergent fiber (ADF), organic matter (OM), starch, titanium, crude protein and whole rumen contents and duodenal samples were analyzed for purine concentration to analyze microbial flow. The purine: nitrogen ratio measured was 0.153 ± 0.011 and individually measured ratios were used to determine nutrient flow through each animal within each period. Whole rumen microbial isolates were composited by treatment and analyzed for OM and starch to correct microbial OM and starch reaching the duodenum, thus calculating true ruminal digestibility. Orts were removed daily and dried for 48h in a 60°C forced-air oven to determine DMI. Feed ingredients and diet refusals were analyzed for the same nutrients analyzed in fecal and duodenal samples. Ruminal pH was recorded every minute using wireless pH probes inserted in the rumen from days 15 to 21.

Nutrient digestibility, VFA and NH_3 analysis were analyzed using the MIXED procedures of SAS, with period and treatment considered fixed effects, and heifer within period considered a random effect. Heifer within the period was considered the experimental unit. Ruminal pH parameters were analyzed using the GLIMMIX procedure of SAS. *P*-values below 0.05 were considered significant.

Results

There was an interaction ($P \leq 0.02$) between corn processing and DDGS treatment for apparent total tract starch digestibility and post ruminal starch digestibility (Table 2). For apparent total tract starch digestibility, SFC-based diets had similar starch digestibility ($P > 0.10$) whether feeding 0% or 30% DDGS or HiPro. Apparent total tract starch digestibility was 95.1% for DRC-CON, was decreased ($P < 0.01$)

Table 1. Diet composition (DM basis) fed to fistulated steers to evaluate nutrient digestion.

	Treatment[1]					
	CON		DDGS		HiPro	
	DRC	SFC	DRC	SFC	DRC	SFC
Ingredient						
Dry-Rolled Corn	87.0	-	57.0	-	57.0	-
Steam Flaked Corn	-	87.0	-	57.0	-	57.0
DDGS	-	-	30.0	30.0	-	-
High Protein DDGS	-	-	-	-	30.0	30.0
Sorghum Silage	8.0	8.0	8.0	8.0	8.0	8.0
Dry Supplement[2]	5.0	5.0	5.0	5.0	5.0	5.0
Nutrient Composition[3]						
Crude Protein, %	12.91	12.64	15.22	15.04	17.50	17.33
Starch, %	62.68	62.85	44.58	44.70	44.13	44.20
NDF, %	14.35	13.44	21.73	21.73	23.39	22.80
ADF, %	7.53	7.25	10.56	10.37	12.97	12.80
Ether Extract, %	3.96	3.10	5.35	4.79	5.17	4.61

[1]Treatments were control (CON), conventionally produced DDGS included in the diet at 30% (DDGS) or high protein DDGS included in the diet at 30% (HiPro), fed with either dry rolled corn (DRC) or steam flaked corn (SFC)

[2]Supplement formulated to be fed at 5.0% of diet DM. Supplement consisted of 1.3925% fine ground corn in the CON supplement and 2.7925% fine ground corn in the DDGS and HiPro supplement, and 1.4% urea in the CON supplement and 0% urea in the DDGS and HiPro supplements, 1.50% limestone, 0.125% tallow, 0.30% salt, 0.05% trace mineral package, 0.015% Vitamin A-D-E package as a percentage of the final diet. It was also formulated for 30 g/ton Rumensin*(Elanco Animal Health, DM Basis) and 8.8 g/ton Tylan* (Elanco Animal Health, DM basis).

[3]Based on analyzed nutrients for each ingredient.

to 92.0% for DRC-DDGS, and further decreased ($P < 0.01$) to 88.7% for DRC-HiPro. Post ruminal starch digestibility followed a similar trend, where SFC-based treatments did not differ from one another ($P > 0.10$) However, cattle fed DRC-based diets haddecreased post ruminal starch digestibility with the inclusion of either DDGS source. Digestibilitywas 77.6% for DRC-CON, 74.7 for DRC-DDGS, and 59.3% for DRC-HiPro.No other interactions were observed.

Distillers Grains plus Solubles Treatment

Feeding either conventional DDGS or HiPro resulted in greater DMI, OMI, NDF and ADF intake ($P < 0.01$) compared to not including DDGS in the diet, with no differences ($P > 0.10$) between the two DDGS treatments for these variables ($P < 0.01$; Table 2). Starch intake was similar between the DDGS treatments ($P = 0.15$), suggesting that even though cattle consuming DDGS or HiPro had lower starch in the diet, they consumed enough DM to compensate. This increased flow and volume of feed through the digestive tract may partially explain the observed lower starch and OM digestibility for DDGS and HiPro treatments as compared to CON. Total tract dry matter digestibility was lower in diets containing conventional DDGS and HiPro diets (71.7 and 68.1%, respectively) as compared to CON diets (76.9%) ($P < 0.01$). Similar results were also observed for OM digestibility. Neutral detergent fiber and ADF digestibility were not different between dietary treatments ($P \geq 0.36$), despite cattle consuming DDGS and HiPro having greater NDF and ADF consumption due to the inclusion of DGS in the diet ($P < 0.01$). As with DMD and OMD, digestible energy of the diet was lower for cattle consuming DDGS and HiPro as compared to the CON treatment ($P < 0.01$). Apparent OM rumen digestibility was lower ($P = 0.02$) for DDGS and HiPro fed cattle as compared to CON, but this was not observed when microbial activity was considered and true OM digestibility was calculated ($P = 0.38$; Table 3). Apparent ruminal starch digestibility was similar to apparent ruminal OM digestibility, in that DDGS and HiPro had lower apparent ruminal starch digestibility than CON ($P < 0.01$). However, this did not translate to differences in true ruminal starch digestibility ($P = 0.11$). Microbial OM flow to the duodenum was greater for DDGS and HiPro (5.40 and 6.26 lb/d, respectively ($P = 0.05$)) as compared to CON (3.44 lb/d). As a result of increased intake and microbial OM flow to the duodenum, total OM flow to the duodenum was greater for DDGS and HiPro as well. Microbial efficiency (g N produced/kg truly fermented OM) was unaffected by treatment ($P = 0.13$), but microbial starch content was greater for DDGS and HiPro fed cattle($P < 0.01$) suggesting some starch engulfing by protozoa may have occurred in the rumen, allowing for flow past the rumen and digestion in the small intestine. There were no differences between treatments for total starch flow to the duodenum ($P = 0.31$), likely because cattle consuming DDGS and HiPro consumed enough extra DMI to make up for their lower starch diets.

Ammonia levels were lower for DDGS and HiPro diets as compared to CON ($P < 0.01$), but the supplement for CON treatments included urea, while this was not included in DDGS and HiPro treatments (Table 4). Rumen ammonia levels were below the minimum 5.0 mg/dL in the SFC-HiPro treatment and were around 8.0 mg/dL for the DDGS treatment, suggesting RDP in the diet may have limited microbial activity. Measured ruminal pH parameters such as maximum, minimum and average ruminal pH were not affected by DGS treatment ($P \geq 0.21$). Ruminal pH variance was greater for the CON treatments as compared to DDGS and HiPro treatments ($P < 0.01$), and the HiPro treatment tended to spend less time below a pH of 5.6 compared to other treatments ($P = 0.08$).

Corn Processing Treatment

Consistent with other research trials, SFC tended to have greater OM digestibility than DRC ($P = 0.08$) and had lower NDF and ADF digestibility than DRC ($P \leq 0.03$; Table 2). Gross energy intake was greater for DRC, likely due to the tendency for greater DMI for the DRC treatment ($P = 0.07$). Total digestible nutrients and DE as a percent of GE were not different between corn processing treatments , averaging 70.6% DE for DRC and 72.3% for SFC. Apparent ruminal OM digestibility was greater for SFC ($P = 0.05$) but was reversed and

Table 2. Effect of high protein DDGS and corn processing method on apparent total tract nutrient digestibility of dry rolled corn or steam flaked corn-based diets

	Treatment[1]									
	CON		DDGS		HiPro			*P*-Value[2]		
Item	DRC	SFC	DRC	SFC	DRC	SFC	SEM	Corn	Distiller	Int.
Dry Matter										
Intake, lb/day	17.50	12.79	19.00	18.45	19.78	18.87	2.12	0.07	0.01	0.26
Digestibility, %	76.1	77.6	71.3	72.1	66.0	70.1	1.91	0.13	0.01	0.56
Organic Matter										
Intake, lb/day	17.13	12.41	18.32	17.75	19.22	18.30	2.033	0.06	0.02	0.24
Digestibility, %	77.8	79.8	73.0	74.1	67.5	71.9	1.94	0.08	0.01	0.59
NDF										
Intake, lb/day	2.58	1.74	4.17	3.92	4.52	4.21	0.454	0.09	0.01	0.62
Digestibility, %	54.6	26.7	52.8	37.8	46.4	34.3	5.30	0.01	0.49	0.23
ADF										
Intake, lb/day	1.34	1.01	1.92	1.83	2.49	2.34	0.238	0.18	0.01	0.73
Digestibility, %	54.0	39.9	54.9	43.1	56.4	52.1	5.63	0.03	0.36	0.60
Starch										
Intake, lb/day	11.24	8.55	8.97	8.58	9.04	8.60	1.043	0.03	0.15	0.13
Digestibility, %	95.1[a]	97.8[d]	92.0[b]	96.1[ad]	88.7[c]	96.2[ad]	0.71	0.01	0.01	0.01
Energy										
GE Intake, Mcal/d	36.35	25.35	41.17	39.16	43.28	40.39	4.238	0.04	0.01	0.27
DE Intake, Mcal/d	27.00	19.39	28.95	27.76	28.11	27.87	3.017	0.08	0.04	0.18
DE, % of GE	75.3	76.6	70.7	71.2	65.7	69.0	1.91	0.24	0.01	0.70
TDN	78.58	76.04	76.68	75.68	72.00	74.02	2.057	0.74	0.08	0.48

[1]Treatments were control (CON), conventionally produced DDGS included in the diet at 30% (DDGS) or high protein DDGS included in the diet at 30% (HiPro), fed with either dry rolled corn (DRC) or steam flaked corn (SFC)

[2]Int = *P*-value for the interaction of corn processing method and DGS treatment. Corn = *P*-Value for the main effect of corn processing effect. Distiller = *P*-Value for the main effect of DDGS treatment

tended to be lower when microbial OM was considered ($P = 0.09$; Table 3). Apparent and true ruminal starch digestibility were greater ($P < 0.01$) for SFC as compared to DRC. Apparent ruminal NDF was lower for SFC as compared to DRC ($P < 0.01$). Microbial, feed, and total starch entering the duodenum was greater for DRC as compared to SFC ($P \leq 0.04$), likely due to lower starch digestibility and greater starch intake of the DRC-based diets. These results were anticipated, as cattle consuming SFC typically eat less due to the fermentability and availability of starch in the grain. Ammonia concentration in the rumen was lower for SFC than DRC ($P < 0.01$), suggesting less fermentation, of DRC-based diets (Table 4). Measured ruminal pH parameters were not different between corn processing treatments ($P \geq 0.21$).

Conclusions

Feeding high protein distillers grains as compared to conventional DDGS did not result in any appreciable differences in rumen fermentation, but feeding high protein distillers decreased digestion of DM and OMStarch digestion was decreased by feeding either type of DDGS in DRC diets but was did not impact starch digestion in diets based on SFC. Starch digestion was not improved by high protein DDGS as hypothesized but actually decreased digestion some compared to conventional DDGS.

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Table 3. Effect of high protein DDGS on ruminal and duodenal total tract nutrient digestibility of dry rolled corn or steam flaked corn-based diets

	Treatment[1]									
	Control		DDGS		HiPro			*P*–Value[2]		
Item	DRC	SFC	DRC	SFC	DRC	SFC	SEM	Corn	Distiller	Int.
Ruminal Digestibility, %										
Apparent OM	47.6	41.9	34.4	35.7	40.4	29.7	3.85	0.05	0.01	0.15
True OM	66.6	72.7	64.3	67.0	62.9	71.2	3.99	0.09	0.38	0.71
Apparent Starch	75.9	84.6	66.4	77.7	71.6	72.7	3.92	0.01	0.01	0.15
True Starch	76.9	86.8	68.6	83.0	75.6	85.3	3.60	0.01	0.11	0.67
Apparent NDF	56.4	11.7	47.4	31.1	52.0	22.7	7.00	0.01	0.80	0.13
Duodenal Flow, lb/d										
Microbial OM	3.06	3.81	5.34	5.49	4.23	7.65	1.010	0.08	0.05	0.19
Feed OM	5.93	3.42	6.77	5.89	7.36	5.16	1.177	0.04	0.25	0.73
Total OM	8.99	7.23	12.10	11.38	11.62	11.42	1.552	0.63	0.01	0.31
Microbial Efficiency[3]	14.40	16.22	21.71	17.23	16.07	19.87	2.143	0.81	0.13	0.10
Microbial Starch	0.11[a]	0.17[a]	0.20[a]	0.46[b]	0.35[ab]	1.0[c]	0.106	0.01	0.01	0.02
Feed Starch	2.76	1.23	3.00	1.57	2.25	1.26	0.529	0.01	0.21	0.71
Total Starch	2.87	1.43	3.20	2.01	2.60	2.36	0.569	0.01	0.31	0.21
Post Ruminal Digestibility, % Entering										
OM	56.8[b]	65.4[c]	58.6[bc]	59.5[bc]	45.5[a]	59.2[bc]	2.75	0.01	0.01	0.05
Starch	77.5[bc]	86.0[8]	74.7[c]	82.4[ab]	59.1[d]	83.5[ab]	3.34	0.01	0.01	0.02

[1]Treatments were control (CON), conventionally produced DDGS included in the diet at 30% (DDGS) or high protein DDGS included in the diet at 30% (HiPro), fed with either dry rolled corn (DRC) or steam flaked corn (SFC)

[2]Int = *P*-value for the interaction of corn processing method and DDGS treatment. Corn = *P*-Value for the main effect of corn processing effect. Distiller = *P*-Value for the main effect of DDGS treatment

[3]Bacterial Efficiency, g N/kg of OM truly fermented

Table 4. Effect of DDGS type and corn processing method on ruminal VFA and ammonia concentration

	Treatment[1]									
	Control		DDGS		HiPro			*P*–Value[2]		
Item	DRC	SFC	DRC	SFC	DRC	SFC	SEM	Corn	Distiller	Int.
Ammonia, mg/dL	19.99	14.01	10.25	6.15	8.80	3.93	1.449	0.01	0.01	0.73
Ruminal pH										
Minimum pH	5.19	5.42	5.44	5.35	5.41	5.74	0.162	0.21	0.21	0.35
Maximum pH	6.78	6.76	6.67	6.61	6.54	6.78	0.213	0.75	0.78	0.70
Average pH	5.87	6.08	6.01	5.91	5.94	6.28	0.185	0.30	0.62	0.41
pH Variance	0.153	0.139	0.072	0.107	0.068	0.069	0.0276	0.73	0.01	0.63
Time < 5.6 min/d	534	352	435	422	195	58	157	0.40	0.08	0.86

[1]Treatments were control (CON), conventionally produced DDGS included in the diet at 30% (DDGS) or high protein DDGS included in the diet at 30% (HiPro), fed with either dry rolled corn (DRC) or steam flaked corn (SFC)

[2]Int = *P*-value for the interaction of corn processing method and DDGS treatment. Corn = *P*-Value for the main effect of corn processing effect. Distillers = *P*-Value for the main effect of DDGS treatment

[3]Ruminal volatile fatty acids (VFA).

[4]VFA concentration in mol/100 mol

[5]Acetate:Propionate

Comparison of Rumen Undegradable Protein Content of Conventional and Organic Feeds

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Summary with Implications

Knowledge of a feed ingredient's protein content and degradability is important in formulating diets for growing cattle. However, there are limited data on protein composition and digestibility of feeds produced in an organic production system. Two studies were conducted using an in situ mobile bag procedure to compare feeds raised in organic and conventional production systems for rumen undegradable protein (RUP) content and digestibility. No differences were observed for RUP content between organic or conventional sources for dehydrated alfalfa, field peas, or expeller pressed soybean meals. Solvent extracted soybean meals were lower in RUP content than expeller pressed soybean meals. Digestibility of RUP was lower for conventional dehydrated alfalfa compared to organic dehydrated alfalfa in Experiment 1 but not in Experiment 2; no other differences in RUP digestibility were observed between conventional and organic feeds. Expeller pressed soybean meals were consistently highest in digestible RUP as a percent of DM with the exception of SoyPass, a soybean meal treated to increase RUP content. These data suggest that feeds produced in organic or conventional systems are not different in RUP content or digestibility and that processing method appears to have greater effect on protein degradability than the production system.

Introduction

Balancing protein in cattle diets is typically done using the metabolizable protein (MP) system. Metabolizable protein is the summation of the protein available to cattle from different sources, including the protein from feed that escapes microbial degradation in the rumen, called rumen undegradable protein (RUP), and the protein from microbes that pass out of the rumen with the ingested feed, called microbial crude protein. The portion of crude protein (CP) from feed that is degraded by microbes is rumen degradable protein (RDP) and contributes to the microbial crude protein supply. Protein requirements are affected by age and growth; for example, animals that are younger or growing more rapidly have greater MP requirements thanmature or slower growing cattle. High forage diets typically do not meet the metabolizable protein requirement of lightweight growing calves, particularly when grazing or fed ensiled forages. While the crude protein content of grazed forages may be high, the majority of that CP is highly degradable in the rumen. Therefore, RUP content is low, and the digestibility of that RUP is low relative to concentrates such as soybean meal. Lightweight calves are small enough that the microbial crude protein supply that washes out the rumen with ingesta may be insufficient to supply protein to support adequate gains. Additional RUP supplied in order to meet MP requirements will improve performance of lightweight growing cattle in most situations.

Due to the requirements of organic beef production, cattle must have access to pasture at a minimum of 30% of their intake throughout the growing season. Because of the grazing requirement, calves raised in an organic production system would likely benefit from supplemental RUP. However, there are limited data examining organic feeds for CP content, and no data available examining RUP content or digestibility. The objective of these two experiments was to evaluate and compare feeds grown in conventional and organic production systems for RUP content and digestibility. Knowing RUP content and digestibility will allow for fine-tuning of supplementation programs. These organic protein sources are quite expensive relative to conventional feeds, so supplementing to meet yet not exceed requirements is beneficial.

Procedure

Two ruminally cannulated steers paired with two ruminally and duodenally cannulated heifers were utilized for Experiment 1, and two ruminally and duodenally cannulated heifers were used for Experiment 2. Animals were fed twice per day at 7:30 AM and 3:30 PM a diet consisting of 30% alfalfa haylage, 65% dry rolled corn, and 5% supplement at 1.8% of BW on a DM basis. Experiment 1 compared organic and conventional sources of dehydrated alfalfa pellets, field peas, fish meal, and soybean meal (SBM). Additionally, conventional dry rolled corn, alfalfa haylage, heat damaged dehydrated alfalfa pellets, dried distillers grains plus solubles (DDGS), high protein DDGS, roasted field peas, raw and roasted whole soybeans, and SoyPass, a treated soybean meal high in RUP, were also evaluated. The field peas and soybeans were roasted at 80% DM in a forced air oven set to 150 °C for 30 minutes. The conventional SBM in Experiment 1 was processed using a solvent extraction method while organic SBM was expeller pressed, a process that results in heating to higher temperatures than a solvent extraction process. Experiment 2 compared organic and conventional dehydrated alfalfa pellets, fish meal, and SBM. Conventional dry rolled corn, field peas, and alfalfa haylage as well as an organic flax meal were also evaluated. Both solvent extracted and expeller pressed conventional SBM was examined in Experiment 2. The number and type of samples of each feed examined in both experiments are shown in Table 1.

Dehydrated alfalfa pellets, soybeans, dry rolled corn, and field peas were ground through a Wiley Mill using a 6 mm screen, while the fish meals, soybean meals, and flax meal were not ground. The alfalfa haylage was freeze dried and ground

Table 1. Feed ingredients analyzed for RUP content and digestibility using *in situ* procedures

	Number of Samples[1]			
	Experiment 1		Experiment 2	
Item	CON	ORG	CON	ORG
Dry Rolled Corn	1	-	1	-
DDGS[2]	1	-	-	-
High Protein DDGS	1	-	-	-
Field Peas	1	1	1	-
Roasted Field Peas	1	-	-	-
Solvent Extracted Soybean Meal	1	-	2	-
Expeller Pressed Soybean Meal	-	1	2	3
SoyPass	1	-	-	-
Raw Whole Soybeans	1	-	-	-
Roasted Whole Soybeans	1	-	-	-
Fish Meal	1	1	4	3
Alfalfa Haylage	1	-	1	-
Dehydrated Alfalfa[3]	1	1	3	3
Heat Damaged Dehydrated Alfalfa[3]	1	-	-	-
Flax Meal	-	-	-	1

[1] CON = Conventional, ORG = Organic; any feed with multiple samples had samples procured from different sources and/or from different production runs from the same facility

[2] DDGS = Dried Distillers Grains Plus Solubles

[3]All dehydrated alfalfas were pelleted

through a Wiley Mill using a 2 mm screen. All samples were analyzed for CP content via combustion using a Flash Smart™ Elemental Analyzer. After grinding, all feeds were weighed into 5 × 10 cm and 10 × 20 cm dacron bags with a pore size of 50 µm in the amounts of 1.25 g and 5.00 g of as-is sample, respectively. Each sample had 16 of each size of bag for use in the mobile bag procedure, with an additional 4 bags of each size withheld from incubations for use in washout testing. Bags of both sizes were divided equally between animals and incubated in the rumen for 16 hours, replicated over two days.

After rumen incubation, all bags were removed and washed in a washing machine for five cycles of one minute of agitation and two minutes spin. Washout bags were divided equally between the two days. After washing, the 10 × 20 cm bags and both sizes of washout bags were dried in a forced-air oven at 100°C for 24 hours, weighed immediately upon removal, and after at least 24 hours of air-equilibration to obtain DM content. Residues were composited by animal within day and ground through a Cyclotec Sample Mill using a 1 mm screen and analyzed for CP to measure RUP content. Percent CP washout was determined by calculating the amount of CP that left the washout bags during the wash procedure and dividing by the amount of CP that was weighed into the bags.

Immediately after washing, the 5 × 10 cm bags were placed in a pepsin/HCl solution warmed to 37°C and gently stirred every 15 minutes for 3 hours. These bags were then removed, sorted into groups by animal and day, and frozen. When ready for duodenal insertion, the 5 × 10 cm bags were thawed and inserted in the duodenum of the corresponding heifer and retrieved from the feces approximately 18 hours after insertion, rinsed with distilled water, and frozen again. Once all bags were collected they were thawed, dried, and weighed using the same procedure for the 10 × 20 cm bags described above to obtain dry matter content. These bags were then composited by animal (Experiment 1) or by animal within day if enough residue was present (Experiment 2). The composited residues were ground in the same manner as residues from the rumen incubation process and analyzed for CP to calculate RUP digestibility. Digestible RUP content was calculated using the following equation: Digestible RUP Content = CP% × RUP Content% × RUP Digestibility%.. This expresses the proportion of DM that is digestible RUP and is useful in comparing samples of differing CP and RUP content. In both experiments, the fish meals were so degraded after passing through the entire animal that insufficient residue was left for CP analysis, so no data are available for RUP digestibility or digestible RUP content of the fish meals, but all protein digested or washed out of the bag if no residue is left following intestinal insertion.

All data were analyzed using the Glimmix procedure of SAS (9.3, SAS Institute Inc., Cary, NC) with the Tukey adjustment applied. Sample was the experimental unit. Animal was considered a random effect, and day was considered a fixed effect. For washout analysis, day was considered a fixed effect and bag size was a random effect. Means of proportions were determined using the ILINK option. Differences were significant at an α value less than or equal to 0.05.

Results

For both experiments, there were no interactions ($P \geq 0.28$) of sample and day for any variable. Significant differences in RUP content, RUP digestibility, digestible RUP content, and CP washout were observed between samples ($P < 0.01$; Table 2, Table 3). In examining the direct comparisons of organic and conventional feeds, in Experiment 1 organic expeller pressed SBM had greater ($P \leq 0.05$) RUP content compared to conventional solvent extracted SBM but both were lower ($P \leq 0.05$) in RUP content than SoyPass (Table 2). No differences in RUP digestibility were observed between SBM ($P > 0.05$) but SoyPass had the highest digestible RUP content, followed by the organic SBM, and the conventional SBM was lowest ($P \leq 0.05$). Organic and conventional dehydrated alfalfa pellets did not differ ($P > 0.05$) in RUP content, but RUP digestibility was significantly greater for organic dehydrated alfalfa pellets than conventional dehydrated alfalfa pellets ($P \leq 0.05$); digestible RUP content was not different between organic and conventional dehydrated alfalfas ($P > 0.05$). No differenc-

Table 2. Experiment 1. Comparison of in situ RUP content and digestibility of organic and conventional feeds

	Item[1]				
Sample[2]	Initial CP, % of DM	RUP Content, % of CP	RUP Digestibility, % of RUP	Digestible RUP Content, % of DM	Washout, % of CP
Alfalfa					
Haylage	18.1	10.5^{i}	9.5^{h}	0.2^{j}	58.3^{b}
DEHY CON	18.1	15.0^{i}	44.2^{f}	1.2^{ij}	31.0^{de}
DEHY ORG	23.0	16.6^{i}	70.5^{e}	2.4^{hi}	36.8^{d}
HD CON	21.2	53.4^{bc}	17.7^{g}	1.9^{i}	25.2^{ef}
Corn and Corn Byproducts					
DRC	9.2	38.1^{gh}	67.0^{e}	2.1^{i}	10.8^{gh}
DDGS	35.2	28.5^{i}	84.2^{d}	7.5^{fg}	27.3^{e}
HP DDGS	37.1	59.9^{b}	93.5^{bc}	18.7^{c}	5.3^{ij}
Field Peas					
CON	22.4	33.6^{fgh}	91.5^{cd}	6.1^{fg}	18.6^{f}
ORG	25.0	41.0^{def}	93.4^{bc}	8.6^{ef}	7.3^{hi}
RST CON	22.3	25.9^{h}	91.6^{cd}	4.5^{gh}	11.2^{gh}
Fish Meal[3]					
CON	69.7	16.5^{efg}	-	-	79.2^{a}
ORG	68.1	46.8^{cde}	-	-	49.6^{c}
CON Soybeans					
Raw	37.5	44.9^{cde}	96.7^{abc}	14.9^{cd}	5.7^{ij}
Roasted	37.0	50.5^{bcd}	97.3^{ab}	16.3^{cd}	3.1^{j}
Soybean Meal					
SoyPass	48.9	78.5^{a}	98.9^{a}	33.9^{a}	9.5^{ghi}
SOLV CON	51.2	27.3^{h}	98.5^{a}	12.5^{de}	11.6^{gh}
EXP ORG	47.0	60.0^{b}	98.7^{a}	26.7^{b}	12.3^{g}
SEM	-	2.08	2.00	1.05	1.58
P-Value					
Sample	-	< 0.01	< 0.01	< 0.01	< 0.01
Day	-	0.08	-	-	0.54
*Sample*Day*	-	0.54	-	-	0.96

[1] CP = Crude Protein, RUP = Rumen Undegradable Protein

[2] CON = Conventional, ORG = Organic, DDGS = Dried Distillers Grains plus Solubles, DEHY = Dehydrated, DRC = Dry Rolled Corn, HD = Heat Damaged, HP = High Protein, SOLV = Solvent Extracted, EXP = Expeller Pressed; all feeds are conventional unless otherwise specified

[3] Fish meal had no residue remaining after retrieval from feces for crude protein analysis

[a-j] Means within a column with different superscripts are different (P < 0.05)

es between conventional and organic field peas were observed for any variable ($P > 0.05$). Organic fish meal was significantly ($P \leq 0.05$) greater in RUP content compared to conventional fish meal. However, conventional fish meal had significantly greater CP washout than organic fish meal ($P \leq 0.05$), which may have affected the RUP content values. Organic SBM was similar in RUP content to high protein DDGS ($P > 0.05$) and had the second highest digestible RUP content value in the experiment.

In Experiment 2 (Table 3), organic fish meals were consistently greater in RUP content compared to conventional fish meals ($P \leq 0.05$). No differences were observed between conventional and organic dehydrated alfalfas in RUP content, RUP digestibility, digestible RUP content, and CP washout ($P > 0.05$). Conventional solvent extracted SBM were lower in RUP content and digestible RUP content compared to any of the expeller pressed SBM ($P \leq 0.05$), but conventional and organic expeller pressed SBM were similar in RUP content and digestible RUP content ($P > 0.05$). All SBM samples were similar in RUP digestibility ($P > 0.05$).

In both experiments, the fish meal bags did not have enough residue for CP analysis

Table 3. Experiment 2. Comparison of *in situ* RUP content and digestibility of organic and conventional feeds

	Item[1]				
Sample[2]	Initial CP, % of DM	RUP Content, % of CP	RUP Digestibility, % of RUP	Digestible RUP Content, % of DM	Washout, % of CP
Dry Rolled Corn	8.9	42.8^{cde}	73.3^{d}	2.8^{g}	19.8^{ij}
Field Peas	24.7	47.3^{cd}	88.2^{b}	10.2^{d}	34.0^{fgh}
Flax Meal ORG	39.8	19.7^{h}	76.0^{d}	6.00^{ef}	26.1^{hi}
Fish Meal[3]					
CON 1	66.7	24.8^{gh}	-	-	66.4^{b}
CON 2	71.9	19.5^{h}	-	-	77.9^{a}
CON 3	64.5	29.8^{g}	-	-	53.1^{c}
CON 4	67.4	31.5^{fg}	-	-	49.5^{cd}
ORG 1	69.0	49.8^{bc}	-	-	47.3^{cde}
ORG 2	72.4	57.2^{ab}	-	-	38.6^{ef}
ORG 3	68.0	47.6^{cd}	-	-	51.3^{cd}
Alfalfa					
Haylage	20.3	18.5^{h}	43.7^{e}	1.6^{g}	70.6^{ab}
DEHY CON 1	19.1	46.0^{cde}	77.2^{cd}	6.7^{ef}	35.5^{fg}
DEHY CON 2	19.6	40.5^{de}	78.6^{cd}	6.2^{ef}	39.4^{ef}
DEHY CON 3	17.3	40.7^{de}	74.5^{d}	5.2^{f}	34.7^{fg}
DEHY ORG 1	22.8	44.7^{cde}	83.4^{bc}	8.4^{de}	42.1^{def}
DEHY ORG 2	16.9	43.7^{cde}	75.2^{d}	5.5^{f}	38.0^{f}
DEHY ORG 3	18.9	37.9^{ef}	76.2^{cd}	5.5^{f}	35.2^{fg}
Soybean Meal					
SOLV CON 1	53.5	41.9^{cde}	97.3^{a}	21.8^{c}	25.4^{i}
SOLV CON 2	53.1	42.8^{cde}	96.3^{a}	21.8^{c}	26.9^{ghi}
EXP ORG 1	48.0	59.1^{a}	97.6^{a}	27.6^{ab}	15.4^{j}
EXP ORG 2	46.6	59.3^{a}	98.2^{a}	27.1^{ab}	15.3^{j}
EXP ORG 3	43.7	56.1^{ab}	96.2^{a}	23.5^{bc}	16.8^{j}
EXP CON 1	47.7	61.5^{a}	97.5^{a}	28.5^{a}	20.8^{ij}
EXP CON 2	48.5	59.7^{a}	97.2^{a}	28.0^{a}	22.4^{ij}
SEM	-	2.62	4.20	1.53	1.74
P-Value					
Sample	-	< 0.01	< 0.01	< 0.01	< 0.01
Day	-	0.09	< 0.01	0.15	0.92
*Sample*Day*	-	0.33	0.59	0.87	0.98

[1] CP = Crude Protein, RUP = Rumen Undegradable Protein

[2] CON = Conventional, ORG = Organic, DRC = Dry Rolled Corn, DEHY = Dehydrated, SOLV = Solvent Extracted, EXP = Expeller Pressed

[3] Fish meal had no residue remaining after retrieval from feces for crude protein analysis

[a-j] Means within a column with different superscripts are different (P < 0.05)

after undergoing ruminal and post-ruminal digestion. Therefore, we speculate that post-ruminal DM and CP digestibility, and therefore RUP digestibility, are extremely high for fish meal, and variable between samples. The high and variable CP washout values indicate that *in situ* mobile bag procedures are not an appropriate method for evaluating fish meal using bags with 50 µm pore size.

The high digestible RUP content value for expeller pressed organic and conventional SBM in both studies indicates that expeller pressed SBM may be an excellent source of supplemental RUP when supplementing protein in organic cattle production systems if the soybeans are produced under organic standards.

Conclusion

Feed ingredients produced in organic production systems were not significantly different in rumen undegradable protein

content or digestibility when compared to feeds produced in conventional systems. Expeller pressed SBM regardless of production system had a rumen undegradable protein content of 59% of CP with high digestibility, making it a valuable source of supplemental protein for both conventional and organic beef production systems. These data were inconclusive about the comparison of fish meals, and further research using a method other than the *in situ* mobile bag procedure is needed. Overall, processing method appeared to have more influence on rumen undegradable protein content and digestibility than whether the feed was raised organically.

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Evaluation of Rumen Undegradable Protein Sources Fed in an Organic Production System

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Summary with Implications

Fifty-eight Holstein steers with an initial body weight of 469 lb were fed 1 of 5 dietary treatments containing different rumen undegradable protein (RUP) sources: control with no supplemental protein, field peas, field peas plus fish meal, soybean meal, and SoyPass, a treated soybean meal high in RUP. These protein sources replaced corn in a base diet of 65% dry rolled corn, 30% alfalfa haylage, and 5% supplement in order to balance for metabolizable protein (MP). The objective of this study was to compare how rumen undegradable protein sources that can be found in organic production systems affect the growth and performance of lightweight Holstein steers. Using supplemental RUP to balance for MP improved F:G by 25% in the first feeding phase regardless of RUP source. Over the feeding period, steers in all treatments gained similarly and had similar final body weight, but steers fed field peas plus fish meal tended to be more efficient than other calves. Supplementing field peas or field peas and fish meal did not result in an increase in cost of gain over calves not fed supplemental RUP. Supplemental RUP increased live weight gained by up to 14.2%. These data indicate that using feedstuffs that can be found in organic production systems to supplement RUP can result in improved F:G without increasing cost of gain.

Introduction

In most production systems, the diets need to be adequate for protein to optimize performance. The metabolizable protein (MP) system should be used to ensure adequate types of protein are being used most efficiently. The MP system accounts for the portion of the crude protein (CP) that enters the rumen as degradable protein used by rumen microbes (RDP), and the portion of CP that escapes microbial degradation (RUP). The MP system also accounts for protein contained within the microbes that exit the rumen with ingesta and can be digested by the animal. Existing research suggests that young, growing calves benefit from supplementary RUP. This is the protein component most often deficient in high forage growing diets and must be supplemented in order to meet MP requirements. In an organic beef production system, where requirements dictate pasture must provide 30% of the diet, supplemental RUP is likely required. Using distillers grains as a protein or energy source usually meets the protein needs of a growing calf, but organic distillers grains are not widely available to organic producers. Furthermore, a steady supply of organic feeder calves is important in producing organic beef, and organic dairies may be the most reliable year-round source of organic feeder calves. The objective of this study was to compare sources of RUP and examine their effects on the performance of lightweight Holstein steer calves in a simulated organic production system.

Procedure

This study utilized 58 Holstein steers (initial body weight= 469 ± 55 lb) in a randomized complete block design. Steers were fed individually using the Calan gate system. Initial BW was established by limit-feeding calves an estimated 2% of body weight (BW) of a diet containing 50% alfalfa hay and 50% Sweet Bran (Cargill) over 5 days to equalize gut fill and collecting individual body weights over the last 3 days of limit feeding. The 5 treatments imposed were based on protein source and included control (CON) with no supplemental protein, field peas (FP), field peas and fish meal (FPFM), soybean meal (SBM), and SoyPass (SP). Treatment diets were fed over 3 phases 65 days in length, and all calves were moved to the CON diet at 194 days due to a lack of response to protein inclusion. These steers were not grazed and were treated with antibiotics and antiparasitics as needed.

All diets, except for CON, were balanced for MP using the initial BW for each feeding phase. Amounts of protein source included on a DM basis varied based on the composition of the protein provided by the source; for example, less SoyPass needed to be included compared to soybean meal because SoyPass has a higher RUP content. Phase feeding these protein sources ensured that protein requirements were being met on day 1 of each phase as calves grew and the amount of RUP needed to balance for MP decreased. All diets contained 30% alfalfa haylage in order to mimic the 30% grazed forage requirement of an organic system and the remainder of the diet contained dry rolled corn (Table 1). A supplement meal consisting of fine ground corn and limestone was included at 5% for all diets except FPFM, which had all or a portion of that supplement meal consisting of fish meal. All feed ingredients used were conventionally grown; the soybean meal was solvent extracted. SoyPass is not available as an organic feed, but was included as a positive control. Diets were mixed and offered daily. Feed refusals were collected and weighed weekly, dried for 48 hours in a 60° C forced-air oven to calculate DMI.

Interim weights were collected on the last day of one feeding phase and the first day of the next feeding phase, averaged, and shrunk 4% to account for gut fill and establish final BW for each phase. Because no significant differences were observed after the day 63 (d63) interim BW, only that interim BW will be examined here. At the end of the individual feeding period, calves were limit fed the CON diet at 1.8% of their body weight for four days and individual

Table 1. Diets fed to Holstein steers in four phases to simulate an organic production system

	Dietary Treatment[1]				
Ingredient, %DM[2]	CON	FP	FPFM	SBM	SP
Phase 1, d1 to d63					
Dry Rolled Corn	65	11	35	33	55.25
Alfalfa Haylage	30	30	30	30	30
Fish Meal	-	-	4	-	-
Field Peas	-	54	30	-	-
Soybean Meal	-	-	-	32	-
SoyPass	-	-	-	-	9.75
Supplement	5	5	1	5	5
Phase 2, d64 to d132					
Dry Rolled Corn	65	26	43	42	57.75
Alfalfa Haylage	30	30	30	30	30
Fish Meal	-	-	3	-	-
Field Peas	-	39	22	-	-
Soybean Meal	-	-	-	23	-
SoyPass	-	-	-	-	7.25
Supplement	5	5	2	5	5
Phase 3, d133 to d194					
Dry Rolled Corn	65	43	55	52	61
Alfalfa Haylage	30	30	30	30	30
Fish Meal	-	-	2	-	-
Field Peas	-	22	10	-	-
Soybean Meal	-	-	-	13	-
SoyPass	-	-	-	-	4
Supplement	5	5	3	5	5
Phase 4, d195 to d214					
Dry Rolled Corn	65	65	65	65	65
Alfalfa Haylage	30	30	30	30	30
Fish Meal	-	-	-	-	-
Field Peas	-	-	-	-	-
Soybean Meal	-	-	-	-	-
SoyPass	-	-	-	-	-
Supplement	5	5	5	5	5

[1]CON = Control, FP = Field Peas, FPFM = Field Peas + Fish Meal, SBM = Soybean Meal, SP = SoyPass

weights were collected the last three days and averaged to establish ending BW. Average daily gain (ADG) and feed efficiency (F:G) were calculated.

For the economic analysis, organic prices were sourced using AMS market data during the feeding period. Alfalfa haylage was priced at $257.77/ton DM after being shrunk 15%. Dry rolled corn was $386.43/ton DM with a 2% shrink applied. Soybean meal was priced at $1,020.30/ton DM after a 2% shrink was applied. Due to the lack of market data, organic field peas were priced at $16 per as-is bushel or $622.40/ton DM after a 5% shrink was applied, and organic fish meal was priced equivalent to conventional fish meal at $1,933.80/ton DM after a 5% shrink. SoyPass was priced at $580.94/ton after a 2% shrink. The supplement used in all diets was priced at $152.78/ton DM with a 2% shrink.

Performance and economic data were analyzed as a randomized complete block design using the Glimmix procedure of SAS (9.3, SAS Institute Inc., Cary, NC) with the Tukey adjustment applied. Individual animal was the experimental unit. Treatment and block were considered fixed effects. Treatment averages were calculated using the LSMEANS option of SAS. Frequency data were analyzed using the Glimmix procedure of SAS with means of proportions for the frequency data determined using the ILINK option. Treatment differences were significant at an α value less than or equal to 0.05.

Results

Initial BW was different ($P = 0.03$) among treatments, with SP and FPFM calves weighing the most and CON calves weighing the least; while the FP and SBM groups were intermediate (Table 2). While some differences in initial BW exist, they are quite small. In Phase 1, protein inclusion resulted in differences ($P = 0.03$) in d63 BW with the CON group weighing the least and FP, FPFM, SBM, and SP groups having similar BW. This was expected, since the CON treatment was MP-deficient while all other treatments were balanced for MP and in theory should have performed similarly. There was also a difference ($P = 0.04$) in ADG between treatments, with calves in the CON group gaining the least and the SP group gaining the most; steers fed FP, FPFM, and SBM were intermediate. The differences in d63 BW and ADG resulted in a difference ($P < 0.01$) in F:G in the first phase; the CON group had the highest F:G while steers fed FP, FPFM, SBM, and SP were similar, with supplemental RUP resulting in an approximate improvement in F:G of 25% regardless of source. No difference ($P = 0.20$) in DMI was detected in Phase 1.

Although calves in the CON group started Phase 2 at a BW disadvantage compared to the other treatments, final BW did not differ ($P = 0.25$). This indicates some form of compensation for the protein deficiency imposed upon the CON group, although final BW was not numerically equivalent among treatments. However, no differences ($P \geq 0.43$) were detected for ADG or F:G in the final three feeding phases. Calves in the SP group had significantly greater ($P = 0.02$) DMI than calves fed FP or FPFM, while calves fed CON and SBM were intermediate.

Over the entire individual feeding

Table 2. Performance of Holstein steers individually fed diets with different sources of RUP in a simulated organic production system

	Dietary Treatment[1]						
Item	CON	FP	FPRM	SBM	SP	SEM	*P*-Value
Phase 1, d1 to d63							
Initial BW, lb	466[a]	470[ab]	471[b]	469[ab]	471[b]	1.3	0.03
d63 BW, lb	556[a]	581[b]	587[b]	585[b]	591[b]	7.9	0.03
ADG, lb/d	1.44[a]	1.77[ab]	1.84[ab]	1.85[ab]	1.91[b]	0.116	0.04
DMI, lb	14.9	14.3	14.4	14.9	15.6	0.46	0.20
F:G	10.75[a]	8.06[b]	7.81[b]	8.13[b]	8.19[b]	-	<0.01
Phases 2–4, d63 to d214							
d63 BW, lb	556[a]	581[b]	587[b]	585[b]	591[b]	7.9	0.03
Final BW, lb	874	892	921	931	938	25.1	0.25
ADG, lb/d	2.29	2.27	2.27	2.25	2.38	0.165	0.97
DMI, lb	20.1[ab]	18.1[a]	18.3[a]	19.0[ab]	21.4[b]	0.77	0.02
F:G	8.93	8.00	8.13	8.55	8.93	-	0.43
Overall, d1 to d214							
Initial BW, lb	466[a]	470[ab]	471[b]	469[ab]	471[b]	1.3	0.03
Final BW, lb	874	892	921	931	938	25.1	0.25
ADG, lb/d	1.91	1.97	2.10	2.16	2.18	0.115	0.28
DMI, lb	19.6[ab]	17.6[a]	17.6[a]	19.1[ab]	20.5[b]	0.73	0.02
F:G	10.20	8.92	8.33	8.85	9.35	-	0.06

Note: Means within a row with different superscripts are different ($P \leq 0.05$)

[1]CON = Control, FP = Field Peas, FPFM = Field Peas + Fish Meal, SBM = Soybean Meal, SP = SoyPass

Table 3. Feed cost of gain of Holstein steers individually fed diets with different sources of RUP in a simulated organic production system

	Dietary Treatment[1]						
Item	CON	FP	FPFM	SBM	SP	SEM	*P*-Value
Feed cost, $/ton DM[2]	336.15	414.69	439.93	462.14	348.10	-	-
Total feed cost, $/head	703.58[a]	778.62[a]	799.34[a]	934.65[b]	761.72[a]	32.751	<0.01
Live weight gain, lb/head	409	422	449	462	467	24.6	0.28
Increase in live weight gain, %[3]	-	3.2	9.8	13.0	14.2	-	-
Cost of gain, $/lb	1.75[ab]	1.91[ab]	1.80[ab]	2.06[b]	1.63[a]	0.089	<0.01

Note: Means within a row with different superscripts are different ($P \leq 0.05$)

[1]CON = Control, FP = Field Peas, FPFM = Field Peas + Fish Meal, SBM = Soybean Meal, SP = SoyPass

[2]Organic feed prices: Dry Rolled Corn = $386.43/ton DM with 2% shrink, Alfalfa Haylage = $257.77/ton DM with 15% shrink, Soybean Meal = $1,020.30/ton DM with 2% shrink, Field Peas = $622.40/ton DM with 5% shrink, Fish Meal = $1,933.80/ton DM with 5% shrink, SoyPass = $580.94/ton DM with 2% shrink, Supplement = $152.78/ton DM with 2% shrink

[3]Percent increase in live weight gain compared to calves fed the Control diet

period, in spite of significant differences in initial BW, protein inclusion and RUP source had no effect ($P \geq 0.25$) on final BW or ADG. Dietary treatment did have a significant impact ($P = 0.02$) on DMI with the SP group having the highest DMI and the FP and FPFM groups having the lowest DMI; Calves fed CON and SBM were intermediate in DMI. This difference in DMI resulted in a tendency ($P = 0.06$) for protein inclusion to affect F:G; calves fed FPFM were the most efficient while those fed CON, FP, SBM, and SP were not different.

An economic analysis is included in Table 3, comparing feed costs of gain (COG) for each dietary treatment. Steers fed SBM had the highest total fed cost ($P < 0.01$) with all other treatments being similar. Live weight gained was not different ($P = 0.28$) between treatments but steers fed SBM also had the highest COG ($P < 0.01$) with those fed SP having the lowest COG and the CON, FP, and FPFM groups being intermediate. It is important to note the soybean meal used in this study was solvent extracted and had an RUP content of approximately 30% of CP, while organic soybean meal is expeller pressed and has a greater RUP content at approximately 59% of CP (Schumacher, *2020 Nebraska Beef Cattle Report*, pp. 45–49). If organic soybean meal were fed at inclusions similar to SoyPass, supplementing organic soybean meal would result in a COG of $1.67 per pound.

Conclusion

These data suggest RUP source has a minimal impact on the performance of lightweight Holstein steers. Supplementing RUP to steers fed a diet of 30% alfalfa haylage resulted in up to 14.2% more live weight gained compared to steers fed no RUP. These data indicate a degree of flexibility in formulating least-cost diets for lightweight Holstein calves in an organic production system. However, if protein sources become too expensive, acceptable results can be obtained without supplementing RUP if 30% of the forage is alfalfa or another feed providing similar dietary protein.

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Effect of Supplemental Protein and Glucogenic Precursors on Digestibility and Energy Metabolism

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Summary with Implications

A metabolism study was conducted to evaluate the impact of increasing levels of glucogenic precursors on diet digestibility and acetate clearance. Four supplementation strategies containing 0, 30, 40, and 70 g of supplemental glucogenic potential were supplied to a basal diet of bromegrass hay. Addition of glucogenic potential in the form of rumen undegradable protein improved dry matter, organic matter, and acid detergent fiber digestibility efficiency of acetate utilization in growing lambs fed moderate-quality hay. However, no additive effect of supplementing propionate salts and rumen undegradable protein were observed in this study. This would suggest that rumen undegradable protein requirements must be met to observe effects from increasing levels of glucogenic potential.

Introduction

Supplementation of glucogenic precursors and rumen undegradable protein (RUP) may increase production responses due to improved efficiencies of nutrient utilization. In forage-based production systems, ruminal production of acetate compared to propionate can result in imbalanced acetate:propionate ratio, resulting in negative modifications in energy metabolism. In order to efficiently utilize acetate, animals must have a sufficient supply of glucose coming from propionate or protein serving as glucose precursors. When glucose supply is inefficient, the animal is not able to efficiently utilize acetate causing a decrease in energy utilization. A study isolating the components of modified distillers grains (MDGS; *2019 Nebraska Beef Cattle Report*, p. 29–31), observed that bypass protein contributed greatly to the energy component of distillers improving total digestible nutrients (TDN) in forage-based diets. The hypothesis was that providing increased levels of glucogenic precursors would increase acetate utilization and improve efficiency in growing lambs on a forage-based diet. Therefore, the objective of this study was to determine the effect of supplemental glucogenic potential (GP) on forage digestibility, serum metabolites, and energy utilization of a forage diet.

Materials and Methods

Sixteen crossbred wethers (108 ± 10.3 lb initial BW) were utilized to determine forage digestibility and acetate utilization. Wethers were sorted into 4 blocks based on initial BW in a 4 × 4 replicated Latin Square design. Wethers were randomly assigned within each period to 1 of 4 treatments to provide 0, 30, 40, or 70 g of additional GP: (1) control (**CON**; 0 g of GP), (2) 40 g of NutroCal (**CAP**; Ca-propionate, 30 g of GP; Kemin Industries Inc., Des Moines, IA), (3) 70 g of blood meal and 100 g of feather meal [**BF**; 92.8% crude protein (CP), 61.3% rumen undegradable protein (RUP), 40 g of GP], or (4) combination of CAP and BF (**COMBO**; 70 g of GP). Brome grass hay [8.8% CP, 90.9% organic matter (OM), 71.4% ash-free neutral detergent fiber (NDF_{om}), 44.8% acid detergent fiber (ADF)] was ground with a tub grinder through a 1-inch screen and fed at 2% BW. An ounce of commercial mineral + vitamin premix was offered daily to all wethers.

Periods were 21-d in length allowing for 12 d of diet adaptation, 5 d of total fecal collection, and 4 d for metabolism collections. Wethers were fed brome grass hay twice daily at 0800 and 1700 h, with 50% of daily DM at each feeding. Supplementation occurred at 0730 h daily. Wethers receiving BF supplementation were adapted at levels of 40, 60, and 80% of total supplementation on d 1–3 of each period, respectively. Feed refusals were taken prior to supplementation. On d 12, wethers were placed in metabolism crates at 1700 h for total fecal collection. Fecal bags were emptied and recorded at 0800 and 1700 h daily, fecal samples were composited by period and freeze dried. Feed refusals were taken d 10 to 15 and feed samples taken d 12 and 19 were dried at 60°C for 72 hours to correct for daily dry matter intake. Fecal, feed, and feed refusal samples were ground through a 1-mm screen of a Wiley mill and analyzed for OM, NDF_{om}, and ADF. Digestibilities were calculated using the following equation: (nutrient intake—nutrient output) / nutrient intake.

An acetate tolerance test (ATT) was conducted on d 17 to analyze acetate clearance affected by GP of treatments. Serum acetate clearance rate can be used as an indication of glucogenic potential of a diet and reveal energy efficiency. Jugular catheters were inserted the morning of the ATT, through which a 20% acetic acid solution was infused at 2.75 mL/lb of BW. Blood samples were collected (~7 mL) -1, 0, 1, 3, 5, 7, 10, 15, 30, 60, and 90 min relative to infusion. Serum was filtered with a centrifugal filter device and analyzed for acetate concentration via gas chromatography. Half-life of acetate was calculated as the time required for a 50% decrease from peak serum concentration. Serum were analyzed for glucose concentration by the Biomedical and Obesity Research Core (BORC) of the Nebraska Center for Prevention of Obesity Diseases (NPOD).

On d 19, a blood sample was taken preprandial at 0730 h and 4 h post-prandial at 1230 h via jugular venipuncture and saphenous venipuncture into serum separator vacuum tubes. Serum samples were analyzed for glucose, urea N (SUN), and amino acid concentrations. Glucose and SUN were also analyzed by the BORC lab of NPOD.

Total tract digestibility data were analyzed as a Latin Square design using the MIXED procedure of SAS. Data were

Table 1. Total tract digestibilities for wethers supplemented with glucogenic precursors fed a forage-based diet.

	Supplementation Treatment					
	CON[1]	CAP[2]	BF[3]	COMBO[4]	SEM	*P*-value
DM						
Total intake[5], lb/d	2.28[d]	2.32[c]	2.56[b]	2.68[a]	0.05	< 0.01
Digestibility, %	37.4[b]	36.6[b]	43.0[a]	42.9[a]	0.98	< 0.01
OM						
Total intake, lb/d	2.08[d]	2.14[c]	2.44[b]	2.5[a]	0.04	< 0.01
Digestibility, %	42.6[b]	43.6[b]	49.8[a]	49.8[a]	1.11	< 0.01
NDF_{om}[6]						
Total intake, lb/d	1.54	1.54	1.54	1.54	0.04	0.98
Digestibility, %	44.8	45.2	45.8	45.3	1.28	0.93
ADF						
Total intake, lb/d	1.02[b]	1.02[b]	1.09[a]	1.09[a]	0.03	< 0.01
Digestibility, %	35.6[bc]	35.4[c]	39.2[a]	38.5[ab]	1.31	0.03

[a-d]Means within a row with different superscripts differ ($P < 0.05$).

[1]CON: No supplementation.

[2]CAP: Supplementation of 40 g of NutroCal (Kemin Industries Inc., Des Moines, IA).

[3]BF: Supplementation of 70 g of blood meal + 100 g of feather meal.

[4]COMBO: Supplementation of 40 g of NutroCal + 70 g of blood meal + 100 g of feather meal.

[5]Total intake = basal diet + supplementation.

[6]NDF_{om} = ash-free NDF.

Table 2. Impact of glucogenic precursor supplementation on serum metabolites of wethers fed a forage-based diet.

	Supplementation Treatment					*P*-values		
Measurements	CON[1]	CAP[2]	BF[3]	COMBO[4]	SEM	Trt	Time	Trt x Time
Jugular Glucose mg/dL	55.4	54.1	55.8	55.8	1.93	0.87	< 0.01	0.57
Saphenous Glucose mg/dL	56.7	54.8	55.5	58.0	1.84	0.47	< 0.01	0.16
Jugular SUN[5], mg/dL	11.3[b]	10.6[b]	25.9[a]	25.5[a]	1.12	< 0.01	< 0.01	0.23
Saphenous SUN, mg, dL	11.6[b]	11.2[b]	25.7[a]	25.2[a]	1.09	< 0.01	< 0.01	0.13

[a,b]Means with differing superscripts are different ($P < 0.05$).

[1]CON: No supplementation.

[2]CAP: Supplementation of 40 g of NutroCal (Kemin Industries Inc., Des Moines, IA).

[3]BF: Supplementation of 70 g of blood meal + 100 g of feather meal.

[4]COMBO: Supplementation of 40 g of NutroCal + 70 g of blood meal + 100 g of feather meal.

[5]SUN = serum urea N.

analyzed with lamb serving as experimental unit, with supplementation type and period set as fixed effects. Acetate half-lives were estimated for each animal by regressing the logarithmically transformed acetate concentrations over time. Area under the curves (AUC) were determined for acetate and glucose using the trapezoidal summation method. Serum data was analyzed as repeated measures with time of blood collection serving as repeated factor.

Results

Digestibility of DM and OM were greater ($P < 0.01$; Table 1) for wethers receiving BF and COMBO supplementation compared to the CAP and CON treatments. Treatments had no effect ($P = 0.93$) on NDF_{om} digestibility. Total intake of DM andOM increased ($P < 0.01$) with increasing GP supplementation, which was expected as supplementation increased intake above the 2% BW DMI for CON.

Supplementation had no effect on circulating glucose concentration ($P \geq 0.47$, Table 2) in samples taken from both jugular and saphenous veins. Addition of RUP supplementation in BF and COMBO increased SUN compared to CON and CAP ($P < 0.01$). A time effect was observed ($P < 0.01$) with serum concentrations being lower prepprandial compared to serum concentrations taken post-prandial.

Acetate half-life was not different ($P = 0.39$; Table 3) among supplemental treatments. Acetate AUC was influenced ($P = 0.04$) by supplemental treatments. Wethers fed BF and COMBO had decreased ($P \leq 0.04$) acetate AUC compared to CON wethers. Wethers fed CAP had a tendency ($P = 0.08$) to have a decreased AUC compared to CON. However, glucose AUC was not different ($P = 0.80$) among supplemental treatments.

Conclusion

Results from this study suggest supplementing additional glucogenic precursors in the form of RUP improved efficiency of nutrient and acetate utilization in growing lambs fed a moderate-quality hay. However, no additive effect of supplementing propionate salts and RUP (COMBO) were observed in this study. Nutrient quality of hay fed in this study has potential for a more balanced acetate:propionate ratio which could explain the decreased responses observed from supplementation of glucogenic precursors.

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Table 3. Effect of supplement on acetate tolerance test for wethers consuming a forage- based diet supplemented with glucogenic precursors.

Acetate tolerance test response	Supplementation Treatment				SEM	*P*-value
	CON[1]	CAP[2]	BF[3]	COMBO[4]		
Acetate half-life, min	39	33	26	31	6	0.39
Acetate AUC[5]	298[a]	242[ab]	205[b]	228[b]	24.3	0.04
Glucose AUC	310	310	326	316	15.7	0.80

[a,b]Means with differing superscripts are different ($P < 0.05$).

[1]CON: No supplementation.

[2]CAP: Supplementation of 40 g of NutroCal (Kemin Industries Inc., Des Moines, IA).

[3]BF: Supplementation of 70 g of blood meal + 100 g of feather meal.

[4]COMBO: Supplementation of 40 g of NutroCal + 70 g of blood meal + 100 g of feather meal.

[5]AUC: area under curve.

Evaluation of Ankom F58 Filter Bags Compared to Dacron Bags and Beakers for Analysis of Acid Detergent Fiber

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Summary with Implications

Feed and fecal samples were analyzed to compare three methods of determining acid detergent fiber. Each sample was weighed into both Dacron and Ankom F58 fiber bags and then analyzed using an Ankom fiber analyzer. Results were then compared to the Van Soest beaker method. Ankom F58 bags helped reduce washout of small particles associated with Dacron bags, but fecal samples needed to be incubated in detergent for an extended amount of time to isolate acid detergent fiber material. Utilizing a technique that produces correct acid detergent fiber values is important for producers because these values are used as a proxy for calculating total digestible nutrients of feedstuffs.

Introduction

Forage sources account for over 80% of the feed amounts allocated to a beef animal over their production lifetime. This includes the forage a cow consumes while gestating and lactating, as well as all of the forage consumed during the backgrounding and finishing phases of an animal's life. The importance of understanding the amount of fiber in these forages is important due to its effect on intake, digestibility, and energy availability. Additionally, the acid detergent fiber (ADF) procedure is used by commercial labs to predict total digestible nutrients of feedstuffs. The Ankom Fiber Analyzer was developed to minimize the amount of human error associated with determining fiber in feed samples. This instrument, which was designed to replace the Van Soest method of using beakers, monitors temperature, time, and the number of washes used during each cycle, which increases accuracy and precision across runs. Feed samples are weighed into bags and then placed in the machine to be analyzed. Traditionally Dacron bags were used, which have a pore size of 50 micrometers. Recently, a new Ankom F58 bag was developed, which has a pore size of 25 micrometers. With some samples there can be washout of small particles through the larger pores, conversely, if pores are too small there may be limited removal of soluble material by the detergent solution. The objective of this study was to determine if samples weighed into either Dacron bags or Ankom F58 bags, then analyzed for ADF in the Ankom machine produced similar values as using the Van Soest method of beakers.

Procedure

Four feed samples were collected and ground through a 1-mm screen using a Wiley Mill in order to analyze a variety of forages ranging from low quality to higher quality. Fecal samples were also collected and ground using a 0.5 mm screen in a Tecator cyclotec sample mill following freeze drying. Eight fecal samples were analyzed to help validate any issues found when analyzing samples with very fine grind sizes. All samples were weighed into Dacron bags and Ankom F58 bags in triplicate. Dacron bags had 1.25 grams of sample and Ankom F58 bags had 0.5 grams of sample. No sodium sulfite was used in the bags. Bags were analyzed for ADF using an automated Ankom machine with samples being exposed to 60 minutes of detergent, followed by a cycle of five minute washes. Bags were removed from the machine and dried at 100°C for 24 h to determine ADF content. Additionally, samples were analyzed for ADF in duplicate using the Van Soest beaker method, which utilizes 0.5 g of sample and 0.5 g of sodium sulfite refluxed in ADF solution for 60 minutes and then filtered using a Whatman 541 filter to isolate ADF material. The filters were dried at 100°C for 24 h and then ADF content is determined. Fecal samples were also weighed into Ankom F58 bags in triplicate and analyzed for ADF in the Ankom machine. However, bags were exposed to 75 minutes of detergent followed by a cycle of five minute washes to increase exposure to detergent and help isolate ADF material. Time of incubation was increased after the 60 minute incubation resulted in values that were higher than the beaker values when fecal samples were analyzed. Bags were removed from the machine and dried at 100°C for 24 h to determine ADF content.

Results

Both types of bags produced similar ADF results when compared to beakers for feed samples (Table 1). Feed analyzed ranged from 29 to 50% ADF and differences between methods were less than 2 percentage units for all feeds. Fecal sample ADF values were different between bag types (Table 2). On average, Dacron bags resulted in 12.1 percentage units lower ADF values compared to beakers. This suggests that there was washout of particles from the bag due to the large pore size of these bags coupled with the smaller grind size of the fecal samples. Conversely, Ankom F58 bags resulted in 6.7 percentage units greater ADF values compared to beaker values, suggesting the fecal material was not exposed to detergent for enough time to completely remove ADF soluble material. This may be due to the smaller pore size of these bags. To solve this problem the second set of Ankom F58 bags were incubated for 75 minutes instead of 60 minutes. This extended incubation in detergent resulted in ADF values that were only 2.3 percentage units greater than beaker values. Regression analysis of ADF value relative to incubation time resulted in an equation [y = (-0.26) x + 65.25] to predict the decrease in ADF as incubation time increased. This could

Table 1. Comparing Ankom F58 bags to Dacron bags when analyzing feed samples for acid detergent fiber (ADF) using 60 minute incubation in an Ankom fiber analyzer

Sample	Beaker[1]	Dacron Bag	Ankom F58 Bags
Brome 1	49.34%	48.88%	50.18%
Brome 2	40.50%	42.19%	41.06%
Alfalfa	29.80%	31.13%	29.25%
Oats	31.37%	32.51%	30.36%
Avg. Difference[2]		-0.93	0.04

[1]Beaker—ADF value based on Van Soest beaker method

[2]Avg. Difference—average ADF value difference between Van Soest beaker method and Ankom machine using individual bag type and incubation length

Table 2. Comparing Ankom F58 bags to Dacron bags when analyzing fecal samples for acid detergent fiber (ADF) using the Ankom fiber analyzer

			Ankom F58 Bags	
Sample	Beaker[1]	Dacron Bag	60 min[2]	75 min[3]
Fecal 1	37.22%	26.63%	45.50%	41.00%
Fecal 2	44.43%	33.59%	49.03%	44.50%
Fecal 3	45.26%	30.12%	53.16%	49.10%
Fecal 4	43.01%	32.25%	48.69%	45.00%
Fecal 5	41.90%	34.25%	48.69%	47.10%
Fecal 6	46.34%	28.53%	54.78%	49.30%
Fecal 7	41.33%	22.54%	46.92%	43.40%
Fecal 8	48.45%	42.91%	50.75%	47.0%
Avg. Difference[4]		12.14%	-6.67%	-2.30%

[1]Beaker—ADF value based on Van Soest beaker method

[2]60 min—60 minute incubation in the Ankom machine

[3]75 min—75 minute incubation in the Ankom machine

[4]Avg. Difference—average ADF value difference between Van Soest beaker method and Ankom machine using individual bag type and incubation length

be extrapolated to predict incubation time needed to replicate beaker ADF values.

Conclusion

Acid detergent fiber values of feed and fecal samples in Ankom F58 bags analyzed by the Ankom machine are similar to values determined using the beaker method if incubation of the bags is extended to 75 minutes, which allows the detergent to completely permeate the bag. When compared to the beakers the Ankom machine resulted in values that were within 3.0 percentage units when the longer incubation was used. Although Ankom values were close to beaker values when using the 75 minute incubation, further research on the exact amount of incubation time needed for samples in the Ankom may improve these values. Overall, the small pore size of these bags helps mitigate issues with washout when compared to Dacron bags for fecal samples or feed samples with very fine particles.

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Evaluation of the Water Footprint of Beef Cattle Production in Nebraska

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Summary with Implications

Data were compiled on feed usage to model the amount of water needed to produce beef in typical Nebraska production systems. Production systems where cows were wintered on corn residue utilized 18% less water than systems utilizing native range as a wintering source, because of water allocations. Therefore, the water footprint (gallons of water required to produce one pound of boneless meat) was decreased by 18%. In addition, increasing the dietary inclusion of distillers grains from 0% to 40% decreased the water footprint in the finishing phase by 29%, again based on water allocation. Utilizing corn residue and distillers grains in Nebraska beef cattle systems decreases the overall water footprint of production. Additionally, the water footprint of the systems analyzed was 80% green water as rain, minimizing the environmental impact of beef production on freshwater use and ecological water balance.

Introduction

Agriculture, especially beef cattle production, is accused of being one of the largest consumers of freshwater in the world. While modeling experiments have been conducted to estimate the amount of water needed to produce beef, the methods used to derive these values are commonly vague and results vary dramatically between studies. The variability in current estimates stems from three key sources. The greatest challenge currently is the water requirement of beef cattle production is often not modeled as a system with varying inputs and outcomes, but rather reported as a single value. While this approach may be sufficient for vertically integrated livestock production systems, the technique does not accurately estimate water used by the beef industry as production is complex with numerous scenarios taking place between a calf's birth and slaughter. In addition, there is no consensus on the correct way to assign a water footprint to the feed resources used in cattle production with each model using a different technique. Lastly, the product produced is not always clearly defined. As a result, the water footprint varies significantly depending on whether it is expressed as water required per pound of carcass, pound of boneless beef, or pound of protein. Thus, the objective of this study was to properly model the water requirement of a specific beef production system commonly used in Nebraska from birth to slaughter, and to evaluate the impact of distillers grains in finishing diets on the water footprint.

Procedure

Data from *2010 Nebraska Beef Cattle Report*, pp. 5–7 were analyzed to determine the effects of wintering strategy on the total amount of water used by the system. The study was conducted over 4 years utilizing 217 cows / yr. The objective of the referenced study was to determine the effects of calving date and wintering system on cow and calf performance. Dry matter intake (DMI), average daily gain (ADG), days on feed (DOF), and information on the specific finishing diets utilized were used to model the water footprint of this production system. Additionally, the Cattle CODE program (*2008 Nebraska Beef Cattle Report*, pp. 47–49) was used to model the effects of increasing distillers grains from 0% to 40% of the diet on performance of finishing cattle. Modeled intake and performance data were then used to evaluate the effects of distillers grains on the water footprint of finishing beef cattle.

The water footprint of the beef cattle system described in *2010 Nebraska Beef Cattle Report*, pp. 5–7 was divided and calculated as two segments; the water footprint associated with the cow for one entire year, and the water associated with growing and finishing the calf. For the cow, the water footprint was calculated by adding the estimated amount of water directly consumed by the animal to the amount of water required to produce the forage that was grazed. Eight gallons was chosen to represent an average for daily water intake although diet, weather, and stage of lactation all influence water intake. A water footprint was also calculated for any supplements utilized while grazing. The water footprint for grazed forages was estimated using AUMs and rainfall data collected at GSL; the total amount of water as rain was divided by the amount of forage DM produced as estimated using the AUM. For grazing, a harvest efficiency of 50% was assumed, meaning 50% of the grass produced was grazed while the other 50% was left. Rainfall associated with the 50% grazed or utilized by cattle was included as part of the water footprint for cattle production. Hay has a lower water footprint than native range due to assumptions of greater productivity on hayed acres (meadows) compared to native range. A similar technique was used for other feed sources (total water / production = water footprint) except for distillers grains and corn residue. For both of these feeds, a strategy known as the value fraction method was applied. This method calculates the total revenue associated with a primary product and generates proportions based on the percentage of total revenue each co-product represents. For distillers grains, the value of this co-product represents 19% of the total revenue generated during ethanol distillation thus the overall water footprint to produce corn grain is multiplied by 0.19 to arrive at the water footprint for distillers grains. Similarly, corn residue represents only 5% of the total revenue generated by a corn crop.

Thus, the total amount of water required to produce the corn crop is multiplied by 0.05, then that value is divided by the amount of corn residue produced per unit of corn that was used in the initial revenue calculation.

The total water footprint for the system described is further divided into what is known as a green and blue water footprint. Green water is the water associated with rainfall, and blue water represents the water removed from surface or ground water resources. For this system, the water required to produce grasses in the Sandhills is green water (rain), and any irrigation associated with producing row crops is defined as blue water. Lastly, the total amount of water required for the cow and finishing the calf is summed together and this value represents the total amount of water consumed by the system producing 1 beef carcass. This value is then divided by the amount of boneless meat produced. Water productivity was calculated as the inverse of the water footprint.

Results

The water footprint of ingredients used to model water utilization for the complete beef cattle system and the finishing scenario developed using Cattle Code are presented in Table 1. The effects of utilizing corn residue as a winter grazing source, calving date, and calf system on the water footprint of beef cattle production can be found in Tables 2–4, respectively. Production systems utilizing native range as a winter grazing source required on average 610,150 gallons of water (Table 2) to produce one finished beef calf across the three calving dates and yearling or calf-fed systems compared to systems utilizing corn residue which required 500,678 gallons to produce one finished beef calf. This represents an 18% decrease in the amount of water required to produce beef when corn residue is substituted for native range as a winter grazing source. This assumes that corn residue was available for grazing in close proximity to the summer range and 95% of the water used to grow the corn was allocated to the corn grain. For both systems, over 80% of the water footprint was green, or rainwater. Total blue water use averaged 118 gal/lb of hot carcass weight (HCW) produced.

Month of calving and calving system (Table 3) have small impact on the system's overall water footprint because of the offsetting differences in feed inputs and HCW. However, August calving systems tended to have the smallest water footprint as all the cows in that system were wintered on corn stalks.

For the comparison between calf-fed and yearling finished cattle (Table 4), the yearling cattle were older at slaughter requiring more feed overall; however, the yearling system utilized slightly less water as the water footprint of the grasses grazed was lower than the total mixed ration utilized in the calf-fed scenario.

Table 1. Water footprint of ingredients included in models[1]

	Water footprint, gal / lb DM		
Item	Green[2]	Blue[3]	Total
Ingredient			
Grazed forages			
Corn Residue	2	1	3
Sandhills Native Range	36	0	36
Harvested Forages			
Hay	20	0	20
Alfalfa	70	39	109
Harvested grains			
Dry rolled corn	51	25	76
Corn processing byproducts[4]	28	14	41

[1]Ingredients from *2010 Nebraska Beef Cattle Report*, pp. 5–7 and scenario generated using Cattle CODE

[2]Rain water utilized

[3]Surface and ground water utilized

[4]Distillers grains and corn gluten feed

Table 2. Effects of wintering system on beef cattle system water utilization[1]

	Wintering system	
Item	Native Range	Corn Residue
Total Water use, gal		
Green[2]	507,050	399,185
Blue[3]	103,100	101,492
Total	610,150	500,678
%Green	83	80
% Blue	17	20
Hot Carcass		
Yield, lb	876	866
Blue WF, gal / lb	118	117
Total WF, gal / lb[4]	697	578
Total WP, lb / gal[5]	0.00144	0.00173
Boneless meat[6]		
Yield, lb	613	606
Blue WF, gal / lb	168	167
Total WF, gal / lb	995	826
Total WP, lb / gal	0.00100	0.00121

[1] Modeled using data from *2010 Nebraska Beef Cattle Report*, pp. 5–7; water utilization was calculated over 365 days for cows in their respective systems and calf-system data averaged

[2]Rain water utilized

[3]Surface and ground water utilized

[4]WF = water footprint (water unit / carcass or boneless meat)

[5]WP = water productivity (carcass or boneless meat / water unit)

[6]Assumes 70% of carcass is boneless meat

Table 3. Effects of month of calving on beef cattle system water utilization[1]

	Month of calving		
Item	March	June	August
Water use, gal			
Green[2]	425,870	466,662	399,346
Blue[3]	95,010	106,602	100,167
Total	520,879	573,264	499,513
% Green	82	81	80
% Blue	18	19	20
Hot Carcass			
Yield, lb	823	903	850
Blue WF, gal / lb	115	118	118
Total WF, gal / lb[4]	633	635	588
Total WP, lb / gal[5]	0.00158	0.00157	0.00170
Boneless meat[6]			
Yield, lb	576	632	595
Blue WF, gal / lb	165	169	168
Total WF, gal / lb	904	907	840
Total WP, lb / gal	0.00111	0.00110	0.00119

[1] Modeled using data from *2010 Nebraska Beef Cattle Report*, pp. 5–7; water utilization was calculated over 365 days for cows in their respective systems and calf-system data averaged

[2]Rain water utilized

[3]Surface and ground water utilized

[4]WF = water footprint (water unit / carcass or boneless meat)

[5]WP = water productivity (carcass or boneless meat / water unit)

[6]Assumes 70% of carcass is boneless meat

Table 4. Effects of calf management on beef cattle system water utilization[1]

	Calf system	
Item	Calf-fed	Yearling
Water use, gal		
Green[2]	443,187	433,714
Blue[3]	105,704	96,081
Total	548,891	529,795
% Green	81	82
% Blue	19	18
Hot Carcass		
Yield, lb	861	884
Blue WF, gal / lb	123	109
Total WF, gal / lb[4]	638	599
Total WP, lb / gal[5]	0.00157	0.00167
Boneless meat[6]		
Yield, lb	603	619
Blue WF, gal / lb	175	155
Total WF, gal / lb	911	856
Total WP, lb / gal	0.00110	0.00117

[1] Modeled using data from *2010 Nebraska Beef Cattle Report*, pp. 5–7; water utilization was calculated by averaging all cow system data and calculating water utilization for calf-feds while on feed for 215 days and yearlings grazing for 100 days followed by 146 days in the feedlot

[2]Rain water utilized

[3]Surface and ground water utilized

[4]WF = water footprint (water unit / carcass or boneless meat)

[5]WP = water productivity (carcass or boneless meat / water unit)

[6]Assumes 70% of carcass is boneless meat

Modeled effects of increasing the dietary inclusion of distillers grains in a typical Nebraska finishing diet on the water footprint of the finishing phase are shown in Table 5. In the scenario with no distillers in the diet, the water required in the finishing phase was 243,371 gallons. However, when distillers grains replaced a dry-rolled corn/high-moisture corn blend to 40% of dietary DM, the water utilized in the system decreased to 173,739 gallons. The complimentary effects of increased ADG and the lower water footprint of distillers grains compared to corn decreased the overall water footprint by 29%. In the systems compared, the feedlot sector utilized 35% of the total water while the cow-calf sector utilized the remaining 65%. However, the feedlot sector utilized 63% of the blue water while the cow-calf sector utilized 37% of the blue water.

Utilizing corn residue and distillers grains decreased the water footprint of beef cattle production considerably; however, it is also important to focus on the use of green vs. blue water. In the complete beef systems modeled in this report, more than 80% of the water footprint was green water. Correctly quantifying and allocating blue and green water usage is essential when measuring the environmental impact of beef cattle production as green water falls as rain and does not require energy inputs to obtain, further increasing resource efficiency. Additionally, green water utilization likely has little impact on freshwater use and the hydrological cycle when the water is consumed by grazing animals in the form of grasses. This concept is especially true when grazed grasses are located on lands that would otherwise have no other use as the rain would fall and the grasses grow regardless of herbivory.

Two key questions about current methodology have arisen while completing these water footprints. Distinctions between green and blue water are critical. Green water use has a lower environmental impact than blue water use, and some argue has no impact. Comparing blue water use between systems is more meaningful than total water use. An advantage of cattle production is the ability to raise cattle in environments where green water is plentiful and can be utilized both for drinking and growing feeds. Secondly, the value added method of assigning water footprints to byproduct

feeds is one of several potential methods. Assigning a water footprint to feeds with several products (corn grain, ethanol, corn processing feed products, corn residue) is complex and all current methods have biases or flaws. Improvements in this area are needed. Regardless of these setbacks it is clear that increases in feed use efficiency (more production of beef per unit of feed input) improves water productivity. In these systems over 99% of the water used was for feed production while less than 1% was utilized for drinking water by the animals. This underscores the need for improvements in feed use efficiency as well as water use efficiency by the crops.

Table 5. Effects of distillers grains inclusion in finishing rations on water use during finishing[1]

	Distillers grains inclusion, % of diet DM[2]		
Item	0	20	40
Initial weight, lb	900	900	900
Ending weight, lb	1,450	1,450	1,450
DMI, lb	24.0	24.5	23.5
ADG, lb	3.7	4.1	4.1
DOF	149	134	135
Water footprint, gal			
Green[3]	163,456	135,620	116,231
Blue[4]	79,915	66,627	57,508
Total	243,371	202,247	173,739
Decrease in Total WF, %	-	17	29
Decrease in Blue WF, %	-	17	28

[1]Performance modeled using Cattle CODE; *Nebraska Beef Cattle Report 2008*, pp. 47–49

[2]Control finishing diet (0% distillers grains) contained 44.5% dry-rolled corn, 44.5% high-moisture corn, 7% corn stalks, 4% supplement with distillers grains replacing corn combination in other diets, respectively.

[3]Rain water utilized

[4]Surface and ground water utilized

Implications

While a substantial amount of water is used by the beef industry, it is paramount to understand where and how it is used on a systems basis and not assume a single averaged value. By obtaining this knowledge, a focus on improvement in resource use can be a target. Results of this study indicate the use of winter grazing corn residue and distillers grains are beneficial, as a secondary resource from the primary corn crop is utilized. The results of this study also emphasize the importance of efficiently and systematically utilizing resources. While there is room for improvement, over 80% of the water used to produce beef in a typical Nebraska system is green water, which minimizes the impact of beef production on freshwater use and the hydrological cycle relative to the ecosystem.

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Evaluation of FluidQuip Fiber Stream Dried Distillers Grains plus Solubles on Performance and Carcass Characteristics in Finishing Diets

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Summary with Implications

A finishing study was conducted to evaluate the effect of feeding dried distillers grains plus solubles (DDGS) from the MSC-fiber stream of the FluidQuip post-fermentation fiber separation process compared to conventional DDGS at two inclusion levels (20% and 40% of diet dry matter). Inclusion of DDGS from MSC or conventional processing methods resulted in increased dry matter intake and daily gain. Despite increased gain, feed conversion tended to be worse for MSC DDGS. Daily gain tended to respond quadratically with increasing inclusion of conventional DDGS with gain increasing from 0 to 20% inclusion, but decreasing from 20 to 40%. Inclusion of conventional DDGS resulted in a quadratic response for feed conversion with improved conversion from 0 to 20% inclusion and poorer conversion from 20 to 40%. Feeding MSC DGS resulted in increased gain but worse feed conversion compared to conventional DDGS when included at both 20% and 40% inclusion.

Introduction

Technological changes in the ethanol production process have allowed for post-fermentation fiber separation techniques (Flint Hills Resources, Wichita, KS). Separation of fiber after fermentation allows for increased oil yield and ethanol plant efficiency providing incentive for adoption of these technologies. While the FluidQuip fractioning process allows for increased ethanol production, it creates byproducts that are different in composition from distillers grains previously produced. The removed fiber fraction, termed MSC dried distillers grains (MSC DDGS), can be used similarly to conventional dried distillers grains. Byproducts from different fiber separation technologies have been investigated in finishing diets, but the effects of MSC DDGS have not been evaluated. Thus, the objective was to determine the feeding value of MSC DDGS and compare that to conventionally produced dried distillers grains (CONV DDGS) in beef cattle finishing diets.

Table 1. Composition of dry-rolled and high-moisture corn finishing diets with FluidQuip fiber fraction dried distillers grains (MSC DDGS) or conventional dried distillers grains (CONV DDGS) at 20 or 40% diet DM inclusion

	Treatment[1]				
	CON	20MSC DDGS	40MSC DDGS	20CONV DDGS	40CONV DDGS
Ingredients					
High Moisture Corn	52.5	40.5	28.5	40.5	28.5
Dry Rolled Corn	35.0	27.0	19.0	27.0	19.0
Alfalfa Hay	7.5	7.5	7.5	7.5	7.5
CONV DDGS	-	-	-	20.0	40.0
MSC DDGS	-	20.0	40.0	-	-
Supplement					
Fine Ground Corn	1.78	2.81	2.81	2.81	2.81
Limestone	1.3	1.68	1.68	1.68	1.68
Tallow	0.125	0.125	0.125	0.125	0.125
Urea	1.4	-	-	-	-
Salt	0.3	0.3	0.3	0.3	0.3
Beef Tr. Min.	0.05	0.05	0.05	0.05	0.05
Vit. ADE	0.015	0.015	0.015	0.015	0.015
Rumensin-90	0.017	0.017	0.017	0.017	0.017
Tylan-40	0.011	0.011	0.011	0.011	0.011
Nutrient Composition					
DM	75.3	77.9	80.6	77.9	80.6
CP	12.9	14.2	19.4	14.1	19.2

[1] CON: Corn-based control diet with 60:40 blend of high-moisture and dry-rolled corn; 20MSC DDGS: fiber fractionated dried distillers grains fed at 20% diet DM; 40MSC DDGS: fiber fractionated dried distillers grains fed at 40% diet DM; 20CONV DDGS; Conventional dried distillers grains fed at 20% diet DM; 40CONV DDGS: Conventional dried distillers grains fed at 40% diet DM

Procedure

A 112-day finishing study was performed at the University of Nebraska feedlot near Mead, NE utilizing 240 cross-bred yearling steers (initial BW = 1020 ± 76 lb) to evaluate the effect of feeding MSC dried distillers grains in comparison to conventionally produced dried distillers grains. Steers were long yearlings that were backgrounded through winter and grazed summer pasture prior to study initiation. Steers were limit fed a common diet 5 days

Table 2. Performance and carcass characteristics of yearling steers fed a corn-based control (CON), FluidQuip fiber fraction dried distillers grains, or conventional dried distillers grains at 20 or 40% DM inclusion in finishing diets

	Treatment						*P*-values			
							MSC DDGS		CONV DDGS	
	CON	20MSC DDGS	40MSC DDGS	20CONV DDGS	40CONV DDGS	SEM	F-test	Lin.	Quad	Lin.	Quad
Performance											
Initial BW, lb	1022	1019	1019	1019	1019	2.2	0.52	0.14	0.63	0.15	0.44
Final BW, lb	1465	1479	1502	1497	1479	17.3	0.23	0.04	0.79	0.44	0.10
DMI, lb/d	30.5[c]	31.9[b]	35.0[a]	31.9[b]	33.0[b]	0.57	<0.01	<0.01	0.11	<0.01	0.69
ADG, lb	3.95	4.10	4.31	4.27	4.10	0.151	0.16	0.03	0.83	0.33	0.08
F:G	7.70[ab]	7.78[ab]	8.11[b]	7.47[a]	8.03[b]	-	0.06	0.09	0.57	0.16	0.04
Feeding Value	-	95	87	115	89						
$NE_{m,}$ Mcal/lb	0.76[a]	0.75[ab]	0.72[c]	0.77[a]	0.73[bc]	0.014	0.01	0.03	0.38	0.02	0.08
$NE_{g,}$ Mcal/lb	0.48[a]	0.47[ab]	0.45[c]	0.49[a]	0.46[bc]	0.012	<0.01	0.03	0.38	0.01	0.06
Carcass characteristics											
HCW, lb	923	932	946	943	932	10.9	0.23	0.04	0.79	0.44	0.10
Marbling [1]	528	547	556	559	536	21.9	0.59	0.22	0.79	0.70	0.17
Fat depth, in	0.53	0.56	0.60	0.58	0.60	0.037	0.29	0.06	0.94	0.07	0.63
REA, in^2	13.7	13.6	13.7	13.5	13.3	0.27	0.60	0.88	0.80	0.17	0.85
Calc YG [2]	3.44	3.58	3.72	3.72	3.77	0.155	0.23	0.08	0.98	0.04	0.40

[abc] Values within a row with unique superscripts are different ($P \leq 0.05$)

[1]300 = Slight, 400 = Small, 500 = Modest

[2]Calculated as 2.5 + (2.5 × 12th rib fat, in) + (0.2 × 2.5(KPH, %))—(0.32 × REA, in^2) + (0.0038 × HCW, lb)

prior to initiation of the trial to equalize gut fill. Steers were weighed three consecutive days (d-1, d 0, and d 1) to establish average initial BW. Steers were blocked by initial BW into one of three blocks, with two reps per block, stratified within block and assigned randomly to pens. Pens were assigned randomly to one of five treatments with 8 steers/pen and 6 pens/treatment. Treatments were arranged in a 2 × 2 + 1 factorial with distillers processing method (Conventional or FluidQuip) and inclusion (20% or 40% diet dry matter [DM]) being the factors, plus a corn-based control (CON; Table 1). The composition of MSC DDGS in this study was 91.0% DM, 34.5% CP, 33.7% NDF, and 7.8% Fat, while the conventional DDGS was 92.0% DM, 34.0% CP, 38.2% NDF, and 9.9% Fat. Byproducts replaced a 60:40 blend of high-moisture and dry-rolled corn. All diets contained 7.5% alfalfa hay and 5% supplement. Supplements were formulated to provide 30 g/ton Rumensin® (Elanco Animal Health) and 8.8 g/ton Tylan® (Elanco Animal Health).

Steers were implanted with Revalor-200 (Merck Animal Health) on day 1, fed for 112 d, and harvested at a commercial packing plant (Greater Omaha) where HCW and liver scores were collected on the day of slaughter. Ribeye area, marbling score, and 12th rib fat thickness were recorded after a 48 h chill. Final body weight, average daily gain (ADG), and feed conversion (F:G) were adjusted based on HCW using a 63% dress.

Data were analyzed using the GLIMMIX procedure of SAS (SAS Inst. Inc., Cary, NC) as a randomized block design. Pen was the experimental unit with block analyzed as a fixed effect. Orthogonal contrasts were used to analyze linear and quadratic effects of inclusion of each byproduct. Treatment means were compared when the F-test statistic for treatment was significant, with $P \leq 0.05$ considered significant and $P \leq 0.10$ considered as tendencies. Feeding values were calculated based on feed efficiency (F:G) using the following equation: {(((F:G_{TRT}-F_{CON})/F:G_{CON})/byproduct inclusion, %) +1} * 100. Feed conversion of treatment is denoted as F:G_{TRT}, and F:G_{CON} represents the feed conversion of the control treatment. Net energy for maintenance (NE_m) and net energy for gain (NE_g) values of the diets were calculated using actual intakes and performance.

Results

Dry matter intake increased linearly ($P < 0.01$) with greater inclusion of DDGS from either processing method. Steers fed 40% MSC DDGS had the greatest DMI ($P < 0.01$), with all other byproducts being greater ($P < 0.01$) than the corn-based control. Inclusion of MSC DDGS resulted in a linear ($P = 0.03$) increase in ADG. A quadratic ($P = 0.08$) response was observed in ADG for steers fed CONV DDGS. As dietary inclusion of CONV DDGS increased from 0 to 20%, ADG increased from 3.95 to 4.27 lb/day, and as dietary inclusion increased from 20 to 40% ADG decreased from 4.27 to 4.10 lb/day. Feed:gain had a tendency to increase linearly ($P \leq 0.09$) with increasing inclusion of MSC DDGS, while a quadratic ($P \leq 0.04$) response was observed with increasing

inclusion of CONV DDGS. Feed conversion decreased with increasing inclusion of CONV DDGS from 0 to 20% and increased with increasing inclusion from 20 to 40%. Feed conversion was lowest ($P = 0.02$) for CONV DDGS included at 20% (similar to CON and 20 MSC) with no significant differences between all other treatments ($P > 0.17$).

Carcass weight linearly ($P = 0.04$) increased with inclusion of MSC DDGS, and tended ($P = 0.10$) to respond quadratically with inclusion of CONV DDGS. Backfat tended to increase linearly ($P \leq 0.07$) with increasing inclusion of either byproduct. Calculated YG tended to increase linearly ($P = 0.08$) with inclusion of MSC DDGS and increased linearly ($P = 0.04$) for CONV DDGS. Marbling and ribeye area were not affected by dietary treatment ($P \geq 0.17$).

Feeding MSC DDGS and CONV DDGS resulted in differing effects based on their dietary inclusion. Based on feed conversion, MSC DDGS has a feeding value of 95% and 87% of corn when fed at 20% and 40% of the diet (DM), respectively. Feeding value of CONV DDGS was 115% and 89% of corn when fed at 20% and 40% of the diet (DM), respectively. There was a linear ($P \leq 0.03$) decrease in dietary NE_m and NE_g as MSC DDGS inclusion increased. Increasing inclusion of CONV DDGS also resulted in a linear ($P \leq 0.02$) decrease in dietary NE_m and NE_g. Control and 20% CONV DDGS diets had the greatest dietary NE_m and NE_g while 40% MSC DDGS had the least and 20% MSC DDGS and 40% CONV DDGS were intermediate.

Conclusion

Feeding MSC DDGS improved ADG, but was lower in feeding value when compared to a corn-based control diet. Inclusion of CONV DDGS at 20% improved ADG and F:G, while 40% improved ADG and provided worse F:G compared to the corn-based control. Both MSC DDGS and CONV DDGS tended to increase carcass weight, fat depth, and calculated YG over the corn-fed cattle. Use of MSC DDGS in finishing diets resulted in decreased feeding value when compared to CONV DDGS at 20% of diet (DM) (95% versus 115%), but was similar at 40% of diet (DM) (87% versus 89%).

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Impact of Shade in Beef Feed Yards on Performance, Body Temperature, and Heat Stress

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Summary with Implications

A study using crossbred steers was conducted at a commercial feedyard in Eastern NE to determine the effects of shade on cattle performance, ear temperature, panting scores, and cattle activity. Cattle with shade had greater dry matter intake, average daily gain and lower panting scores while movement and ear temperature were not different between treatments. Over the course of the experiment three weather events were selected to be analyzed separately (two heat events and one cool event) based on wind adjusted temperature-humidity index. Providing shade during heat event 1 resulted in greater intakes and lower panting scores, while providing shade during heat event 2 resulted in lower panting scores compared to non-shaded cattle. During the cool event, greater intakes and lower panting scores were observed for shaded cattle, although panting scores were low for both treatments. Providing shade for cattle improved intakes and average daily gains while mitigating some effects of heat stress.

Introduction

Heat stress in cattle is a concern to both the animal as well as the producer. Heat stress costs the beef industry millions of dollars annually in production losses ranging from decreases in gain to increased death loss. With potential for reduced performance paired with consumer concerns with animal welfare, cattle comfort should be considered. Providing shade to cattle in feedyards will: decrease solar radiation experienced by the animal, and reduce ground temperature, but will have little to no effect on ambient air temperature. The effect of shade on cattle performance depends on location (humid vs dry climate for example), weather (year to year variation), area under the shade (crowding/mud concerns), cattle behavior, among other factors. The objective of this study was to determine the effect of shade on cattle performance, ear temperature, and cattle activity and was the second year of a two-year study. This trial was designed similarly to the year 1 study (*2019 Nebraska Beef Cattle Report*, pp. 85–87) with the main difference being an earlier slaughter date to avoid a cool period that potentially allows for non-shaded cattle to compensate prior to shipping.

Procedure

A study with crossbred steers (n = 1713; initial BW = 834 lb, SD = 23) was conducted at a commercial feedyard in Eastern NE exploring the effects of providing shade to cattle.Cattle were received from February 19 to March 5. Upon arrival cattle were weighed, given Titanium 5 (Elanco Animal Health; Greenfield, IN), injected with Ivermax Plus (Aspen Veterinary Resources; Greeley, Co), poured with Ivermax Pour On (Aspen Veterinary Resources; Greeley, Co), and implanted with Synovex Choice (Zoetis; Parsippany, New Jersey). Cattle were assigned to treatment as they exited the chute by switching a sort gate every third animal. Cattle were fed a common diet during the trial consisting of 63% dry-rolled corn, 20% modified distillers grains plus solubles, 8% corn cobs, 5% wet corn gluten feed, and 5% supplement containing 36.6 g/ton Rumensin, and 9.6 g/ton Tylan (DM-Basis) . Cattle were weighed and re-implanted from May 3 to May 31 depending on receiving date.

The experimental design was a randomized complete block with two treatments and arrival date used as the blocking effect (n=5). Ten pens were assigned randomly to treatment as either having shade (SHADE) or no shade (NO SHADE) provided in the pens, with five pens per treatment. Six of the pens were 200 by 400 feet and 4 of the pens were 135 by 400 feet. The shades were all the same size and are composed of high-density polyethylene monofilament (NetPro; Stanthorpe Qld, Australia) that excludes 70% of sunlight. Cables that run the length and width of pen held the shade 18 feet above pen surface. Given that shade sizes were the same across all pens, then three large and two small pens had shade while 3 large and two small pens did not have shade. Each pen provided 420 ft^2/steer, and shaded large pens provided 30 ft^2/steer of shade while shaded small pens provided 45 ft^2/steer of shade.

A subset of 30 steers from each pen were selected randomly based on processing order and given a Quantified Ag biometric sensing ear tag (Quantified Ag, Lincoln, NE). The tag recorded movement every hour and ear temperature 5 times per hour. One trained technician recorded panting scores on the same subset of animals that had the biometric sensing ear tag at least twice every week from May 29 to July 24 between 1 pm and 5 pm. Panting scores were based on a score of 0 to 4.5 in 0.5 increments with a score of 0 = no panting and 4.0 = open mouth with tongue fully extended, excessive drooling, and neck extended.

The adjusted temperature-humidity index (adjusted THI) values came from a weather station located at the feed yard. Figure 1 shows the maximum, minimum and average adjusted THI throughout the trial as well as three weather events. The Livestock Weather Safety Index uses an adjusted THI of 74 as the threshold for heat stress in cattle. Heat event 1 was from May 24 to June 1, and heat event 2 was from July 9 to July 16. Both events had a maximum THI greater than 74 each day, with multiple days being greater than 80. The cool event was from June 2 to June 7 and was the first five consecutive days following a heat event with an average daily adjusted THI less than 74.

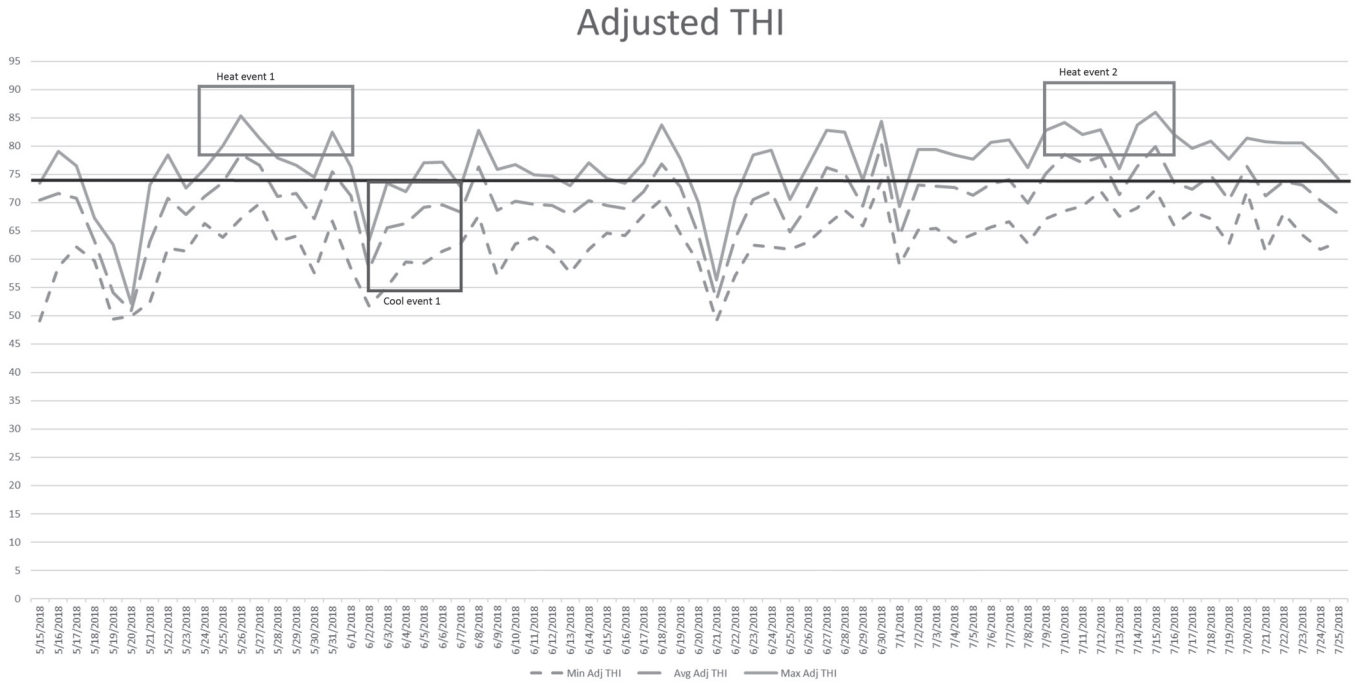

Figure 1. Maximum, minimum, and average adjusted temperature-humidity index (THI) across all days of the trial. The solid line shown at a THI of 74 represents the threshold set by the Livestock Weather Safety Index for heat stress in cattle. Heat event 1 was from May 24 to June 1, cool event 1 was from June 2 to June 7, and heat event 2 was from July 9 to July 16.

Table 1. No shade vs. Shade performance and carcass traits

	Treatments[1]			
Item	No Shade	Shade	SEM	*P*-value
Performance				
Initial BW, lb	835	833	3	0.65
Adjusted Final BW[2], lb	1462	1479	6	0.11
DMI, lb/d	22.9	23.4	0.02	< 0.01
ADG, lb	3.90	4.02	0.03	0.04
F:G	5.87	5.81	0.05	0.47
Carcass				
HCW[3], lb	921	932	4	0.12
LM area[4], in^2	14.1	14.7	0.2	0.06
12th rib fat, in	0.59	0.61	0.01	0.32
Marbling[5]	460	459	4	0.87
Calculated YG[6]	3.42	3.31	0.07	0.32

[1]Treatments consisted of 5 open pens and 5 shaded (30 to 45 ft^2/animal) pens

[2]Adjusted final body weight (BW) calculated from hot carcass weight (HCW) and a common 63% dressing percent

[3]Hot carcass weight

[4]Marbling score: 300 = slight, 400 = small, 500 = modest, etc.

[5]LM area = longissimus muscle (ribeye) area

[6]Calculated Yield Grade (YG) = 2.50 + (2.5 × 12th rib fat, in)-(0.32 × LM area, in^2) + (0.2 × 2.5% KPH) + (0.0038 × HCW, lb)

The first block of cattle was shipped on July 25 and the final block was shipped on August 27. Cattle were harvested at Cargill Meat Solutions (Schuyler, NE). Carcass characteristics, cattle performance, panting scores, and biometric ear tag data were analyzed using the MIXED procedure of SAS (SAS Institute Inc. Cary, NC) with pen as the experimental unit. Panting scores and biometric sensing ear tag data were analyzed as repeated measures, and biometric sensing ear tag data were tested by pen for treatment by hour interactions.

Results

SHADE cattle had greater DMI and average daily gain (ADG) across the feeding period compared to NO SHADE cattle ($P \leq 0.04$), while feed conversion was not impacted ($P = 0.47$; Table 1). Ribeye area tended to increase ($P = 0.06$) while final BW and hot carcass weight (HCW) were numerically greater ($P \leq 0.12$) for SHADE cattle compared to NO SHADE cattle. Ear temperature tended to be greater ($P = 0.08$; Table 2) for SHADE cattle while movement (Figure 2) was not different ($P = 0.31$) between treatments across the entire feeding

Table 2. Main effect of treatment on DMI, panting score, movement, and temperature during weather events

	Treatment			*P*-Value		
Item	No Shade	Shade	SEM	Trt	Hour	Trt*Hour
Total Trial[1]						
Movement	28,858	28,804	395	0.93	< 0.01	0.99
Temperature, °F[2]	97.91	97.96	0.12	0.80	< 0.01	0.31
Panting Score[3]	0.98	0.70	0.02	< 0.01	-	-
Heat Event 1[4]						
Panting Score	0.70	0.27	0.06	< 0.01	-	-
DMI, lb/d	20.0	24.0	0.5	< 0.01	-	-
Cool Event[5]						
Movement	31,694	31,846	472	0.83	< 0.01	0.32
Temperature, °F	98.20	98.54	0.15	0.08	< 0.01	0.27
Panting Score	0.42	0.26	0.04	0.01	-	-
DMI, lb/d	21.6	23.4	0.1	< 0.01	-	-
Heat Event 2[6]						
Panting Score	1.76	1.45	0.05	< 0.01	-	-
DMI, lb/d	22.7	23.3	0.3	0.14	-	-

[1]February 26–July 25

[2]Ear temperature was measured using a biometric sense tag (Quantified Ag, Lincoln, NE)

[3]Panting scores were based on a score of 0 to 4.5 in 0.5 increments with a score of 0 = no panting and 4.0 = open mouth with tongue fully extended, excessive drooling, and neck extended

[4]May 25–June 1

[5]June 2–June 7

[6]July 7–July 16

period. Figure 3 shows cattle movement during heat event 1 where a treatment by hour interaction was observed. NO SHADE cattle moved more from 11 am to 5 pm, and SHADE cattle moved more from 8–9 pm ($P < 0.05$). Figure 4 shows cattle movement during heat event 2 where SHADE cattle moved more from 5–8 pm plus hour 11 pm compared to NO SHADE cattle ($P < 0.05$). Figure 5 shows cattle ear temperature during heat event 1 where a treatment by hour interaction was observed ($P < 0.01$). SHADE cattle had greater temperature from 12–8 am while NO SHADE had greater temperature from 2–8 pm ($P < 0.05$). Figure 6 shows cattle ear temperature during heat event 2 where a treatment by hour interaction was observed ($P = 0.10$). NO SHADE cattle had greater temperature at 3, 5, and 7 pm compared to SHADE cattle ($P < 0.05$). Panting scores were greater for NO SHADE cattle compared to SHADE cattle across the entire feeding period, as well as within both heat events and the cool event ($P \leq 0.01$; Table 2). Dry matter intake was greater during heat event 1 and the cool event ($P \leq 0.01$), while DMI was numerically increased during heat event 2 ($P = 0.14$) for SHADE compared to NO SHADE for cattle experiencing heat events close to slaughter. No differences in performance were detected in year 1, likely due to later slaughter date paired with cooler weather at the end of the feeding period. These results are similar to what was observed in year one for cattle movement as both years suggest shade cattle move at different times of the day compared to no shade during heat events as well as greater panting scores for non-shaded cattle across the entire feeding period both years. One main difference between year 1 and 2 is the difference in intake that was observed in year two was not found in year one. This is a result of multiple factors, including a cool August in year one that potentially allowed the non-shaded cattle to experience compensatory gain.

Conclusion

Cattle provided shade had greater DMI and ADG while having numerically greater final BW and HCW, along with reduced panting scores compared to cattle without access to shade. The greater ADG and subsequent numerically greater final BW and HCW are likely driven by better intakes during heat events. No differences in movement or ear temperature were observed across the entire feeding period. Some differences occurred between treatments within heat events, illustrating that cattle provided shade move at different times of the day while overall movement is not impacted.

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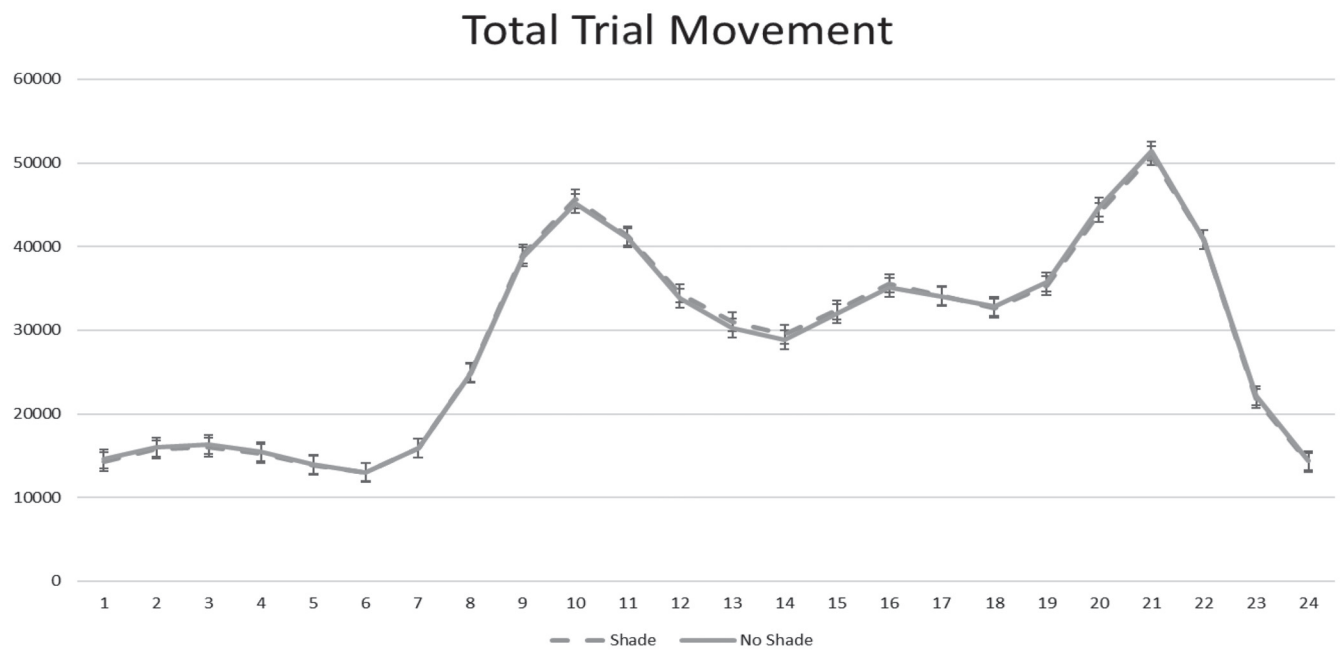

Figure 2. Effect of treatment (SHADE or NO SHADE) on movement of cattle across entire feeding period. Movement was measured using a biometric sense tag (Quantified Ag, Lincoln, NE) that measured total movement.

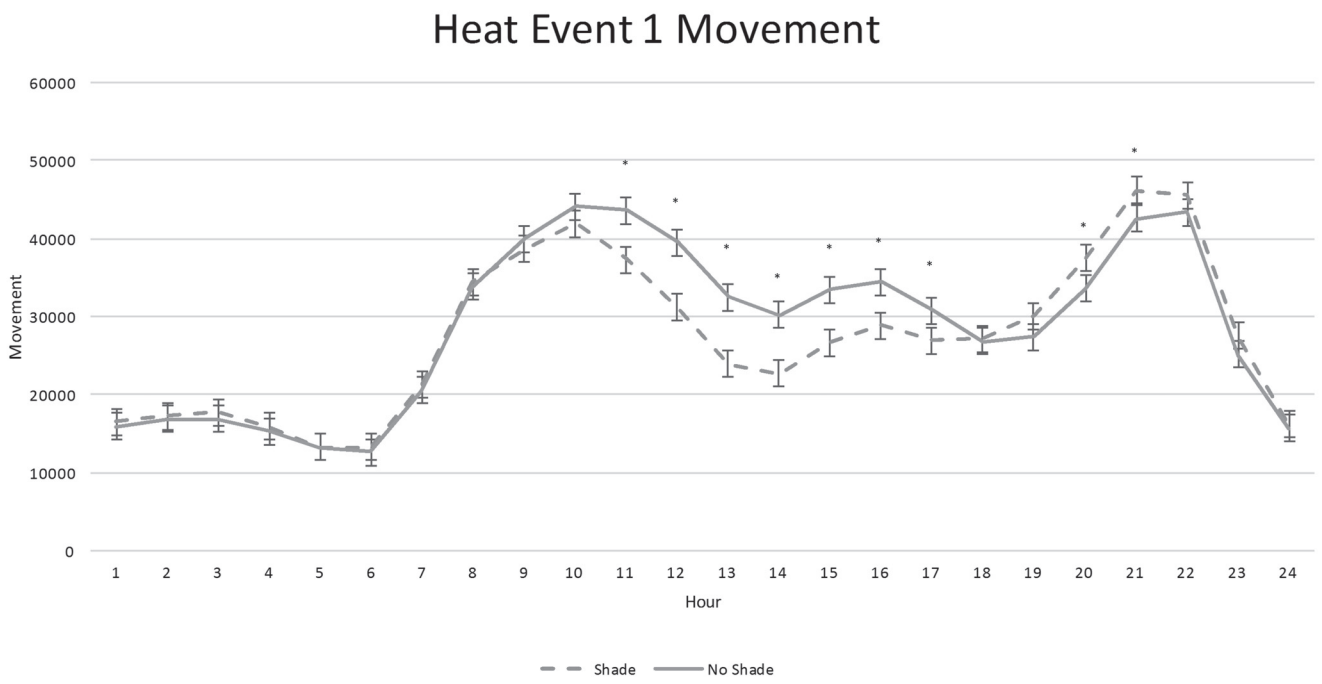

Figure 3. Effect of treatment (SHADE or NO SHADE) on movement of cattle during Heat Event 1 (May 24—June 1). Movement was measured using a biometric sense tag (Quantified Ag, Lincoln, NE) that measured total movement. The interaction between treatment and hour was significant ($P < 0.01$). Treatment difference within hour are significant ($P < 0.05$) at time points denoted with an *.

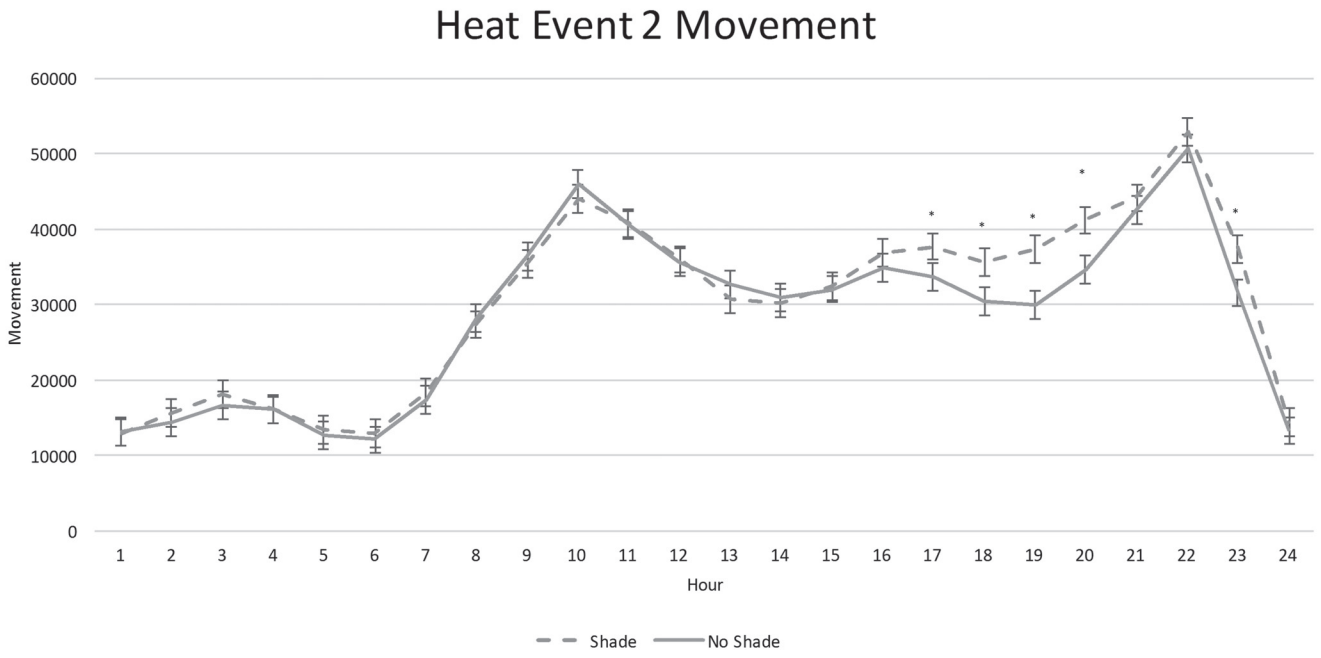

Figure 4. Effect of treatment (SHADE or NO SHADE) on movement of cattle during Heat Event 2 (July 9—July 16). Movement was measured using a biometric sense tag (Quantified Ag, Lincoln, NE) that measured total movement. The interaction between treatment and hour was significant ($P = 0.06$). Treatment difference within hour are significant ($P < 0.05$)at time points denoted with an *.

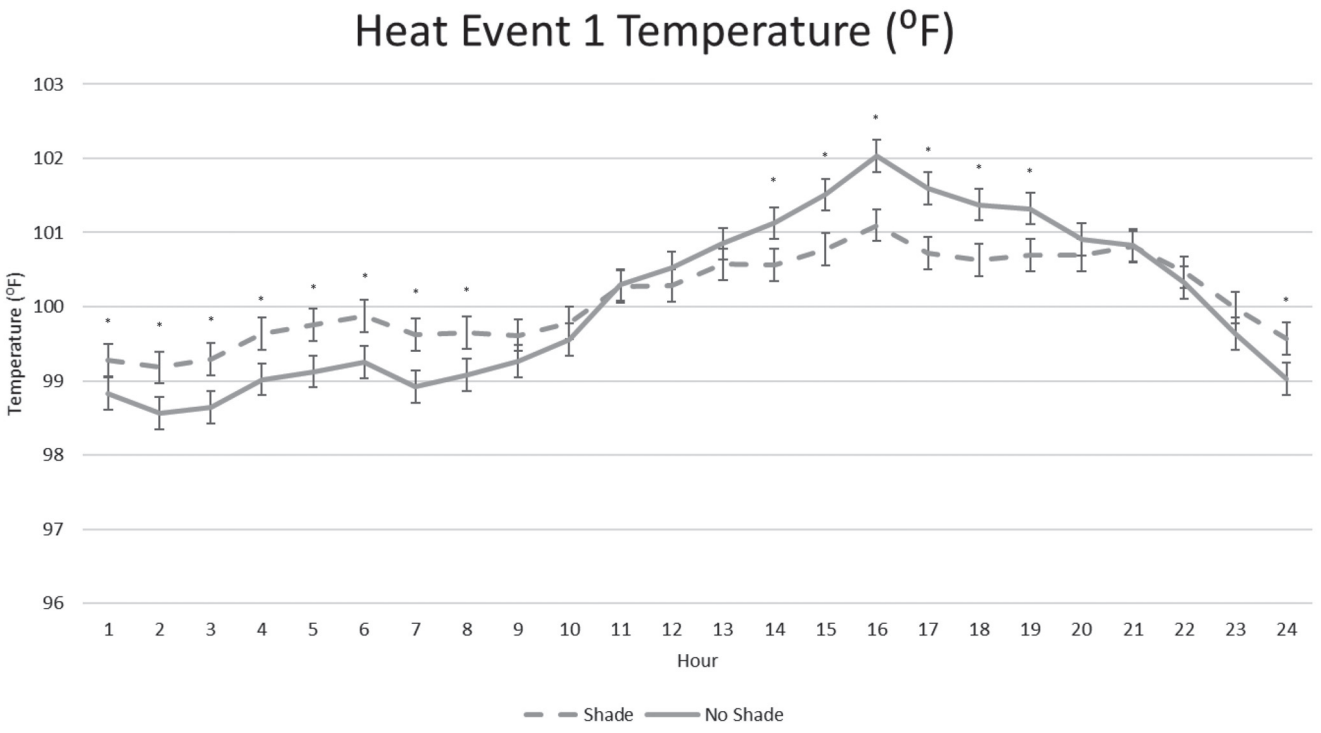

Figure 5. Effect of treatment (SHADE or NO SHADE) on ear temperature of cattle during Heat Event 1 (May 24—June 1). Temperature was measured using a biometric sense tag (Quantified Ag, Lincoln, NE) that measured ear canal temperature. The interaction between treatment and hour was significant ($P < 0.01$). Treatment difference within hour are significant ($P < 0.05$) at time points denoted with an *.

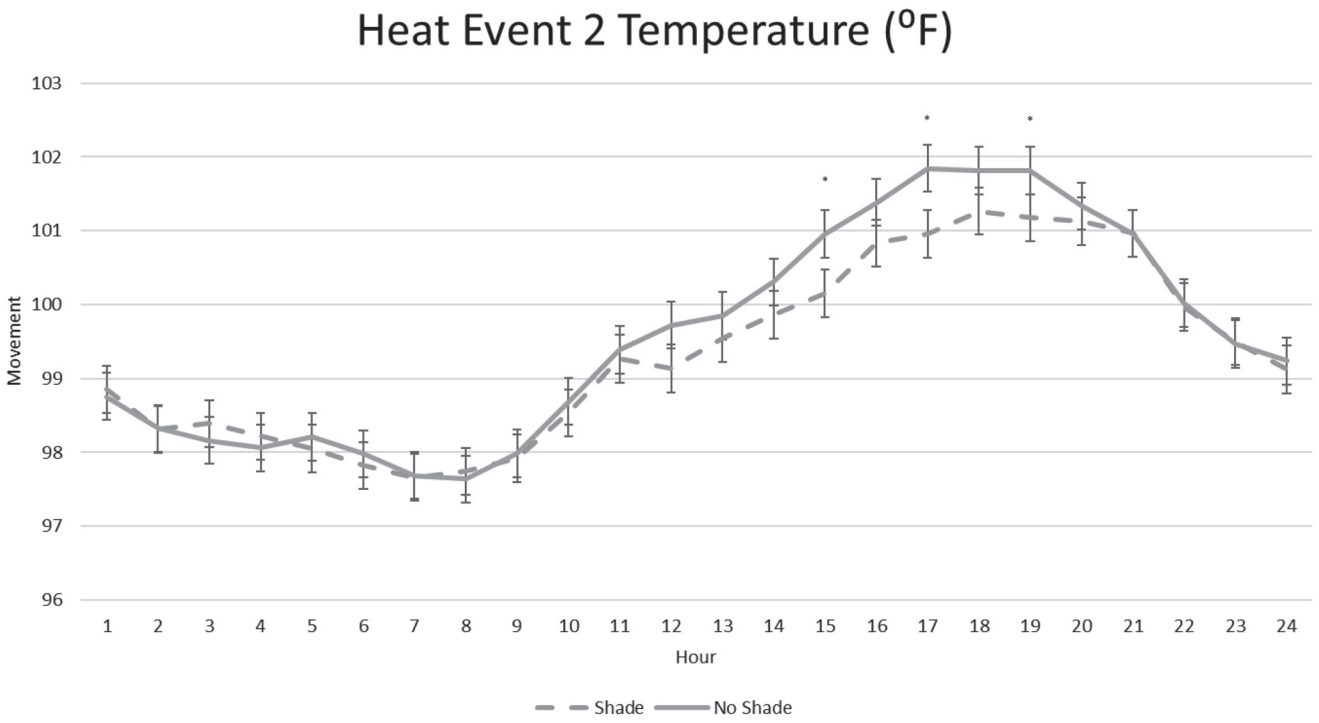

Figure 6. Effect of treatment (SHADE or NO SHADE) on ear temperature of cattle during Heat Event 2 (July 9—July 16). Temperature was measured using a biometric sense tag (Quantified Ag, Lincoln, NE) that measured ear canal temperature. The interaction between treatment and hour was significant ($P = 0.10$). Treatment difference within hour are significant ($P < 0.05$) at time points denoted with an *.

Impact of Essential Oils Blend on Beef Cattle Performance and Carcass Characteristics in Diets with Increasing Corn Silage Inclusions

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Summary with Implications

A feedlot study was conducted comparing a natural feed additive (essential oils blend) at varying corn silage (CS) inclusions (14, 47, and 80%; DM basis) on receiving and finishing performance. Essential oils have been shown to alter the rumen environment leading to improved feed efficiency and production. Cattle were fed 14% CS for 168 days, 47% CS for 195 days, and 80% CS for 238 days to a common backfat of 0.5 inches. There were no interactions between the inclusion of the essential oil blend and corn silage for performance or carcass characteristics. There was no significant difference in performance or carcass characteristics for cattle fed with or without essential oils. Feeding corn silage at greater inclusions decreased gain and increased conversion but increased final body weight when fed to an equal fatness. Additionally, greater inclusions of silage led to increased profitability in dollars per head sold. Essential oils did not affect animal performance or carcass characteristics. However, feeding greater amounts of corn silage can be economical.

Introduction

Increasing restriction on medically important antibiotics in food animal production have led to interest in antibiotic alternatives. Feeding essential oils may help prevent ruminal acidosis, bloat, digestive and metabolic upsets. Essential oils (EO), derived from plant extracts, have been shown to alter ruminal metabolism to improve feed efficiency by manipulating microbial activity in the rumen. In most studies researchers have found a decrease, or no change, in total VFA concentration but observed a shift to more propionate. However, effects of plant extracts on ruminal microbial fermentation are pH dependent. This would be important when evaluating essential oil supplementation in various inclusions of concentrate. Few studies have been performed to evaluate the effects of EO on beef cattle performance. As corn silage is added to a diet replacing corn grain, energy density decreases, and less energy is available for gain. This is a valuable tool to mimic different stages of production to assess the impacts of feed additives at different concentrate levels. The objective of this study was to determine the impact of an essential oils mixture (palm oil and fumaric acid) on the performance and carcass characteristics of beef cattle fed different inclusions of corn silage.

Procedure

A finishing experiment conducted at the Eastern Nebraska Research and Extension Center utilized 480 crossbred steers (initial shrunk BW 652 lbs ± 53.0 lbs). Cattle were limit fed a diet at 2% of BW for 5 d prior to the start of the experiment. Two-day initial weights were recorded on d 0 and 1 which were averaged and used as the initial BW. The steers were blocked by BW into three weight blocks, light, middle, and heavy, (n = 12, 24, and 12 pen replicates, respectively) based on d 0 BW, stratified by BW within block and assigned randomly to 1 of 48 pens. There were 10 steers/pen and 8 replications per treatment. Treatment design was a 2 × 3 factorial with 3 inclusions of corn silage (14, 47, 80) with or without (+, -) the inclusion of an essential oils blend (14 CS +EO, 14 CS -EO, 47 CS +EO, 47 CS -EO, 80 CS +EO, 80 CS -EO; Table 1).

Steers were fed at 80% CS inclusion and adapted to 47% and 14% CS over a 10 and 24-d period, respectively, with dry-rolled corn replacing alfalfa hay and corn silage. Diets were formulated to meet or exceed NRC requirements for protein and minerals. The final finishing diets provided 330 mg/steer daily of Rumensin (30 g/ton of DM; Elanco Animal Health), and 90 mg/steer daily of Tylan (8.2 g/ton of DM; Elanco Animal Health). The +EO supplements were formulated to supply 0.2% of the diet DM as EO (Idena SAS, Sautron, France). The EO blend contained palm oil, fumaric acid, and artificial flavors in a calcium carbonate and sodium sulfate carrier. Steers were implanted on day 1 with Revalor-XS (Merck Animal Health) and received a Bovi-Shield Gold One Shot, Dectomax injection, and Somubac (Zoetis Animal Health). Feed samples were taken weekly, composited on a monthly basis, and analyzed for organic matter (OM), neutral detergent fiber (NDF), acid detergent fiber (ADF), and crude protein (CP).

Cattle fed 80% CS were fed for 238 days, 47% CS for 195 days, and 14% CS were fed for 168 days. Days on feed were determined by estimating finishing backfat using ultrasound. Steers were shipped to Greater Omaha for harvest, and carcass data were recorded. On day of harvest, hot carcass weight was collected. Following a 48-hour chill, USDA marbling score, longissimus muscle (LM) area, and 12th rib fat thickness were recorded. Carcass-adjusted performance was calculated using final body weight (BW), based on hot carcass weight (HCW) divided by a common dressing percentage of 63.

Corn silage economics

Corn silage inclusion was economically evaluated using corn price based on market prices for September ($3.67). Dry corn price was calculated using $3.67 plus an average $0.20 (+ $0.05 per month on feed) with $2.17/ton DM charged for processing costs. Using the $3.67 corn price, a corn silage pricing application from Iowa State University (Silage Pricer-Corn Silage. Version 1.4_82017. Iowa State Extension) was used to price corn silage at $43.99 per ton as-is ($110 /ton DM, 37% DM), which accounted for 15% DM basis silage shrink

Table 1. Composition (% of diet DM) of dietary treatments fed to steers on varying inclusions of corn silage.

	Treatment[1]					
	- EO			+ EO		
Ingredient	14 CS	47 CS	80 CS	14 CS	47 CS	80 CS
Corn Silage	14	47	80	14	47	80
Dry-rolled corn	66	33	-	66	33	-
Modified DGS	16	16	16	16	16	16
Supplement[2]						
Fine Ground Corn	1.2575	1.2575	1.258	1.058	1.058	1.0575
Limestone	1.65	1.65	1.65	1.65	1.65	1.65
Urea	0.6	0.6	0.6	0.6	0.6	0.6
Salt	0.3	0.3	0.3	0.3	0.3	0.3
Essential Oils Blend[3]	-	-	-	0.2	0.2	0.2
Tallow	0.1	0.1	0.1	0.1	0.1	0.1
Beef Trace Minerals Premix	0.05	0.05	0.05	0.05	0.05	0.05
Rumensin[4] Premix	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165
Vitamin A-D-E Premix	0.015	0.015	0.015	0.015	0.015	0.015
Tylosin[5] Premix	0.011	0.011	0.011	-	-	-
Nutrient Composition, % DM						
Organic Matter	96.2	94.9	93.7	96.0	94.7	93.5
Neutral Detergent Fiber	21.9	32.1	42.2	22.0	32.2	42.4
Crude Protein	15.5	15.2	15.0	15.5	15.3	15.0
Ether Extract	4.1	3.9	3.7	4.1	3.9	3.7

[1] CS = corn silage; EO = essential oils.

[2] Supplement fed at 4% of dietary DM for all treatments.

[3] Formulated to supply AL630US (Idena SAS; France) at 0.2% of the diet DM; EO contains palm oil, fumaric acid, and artificial flavors

[4] Formulated to supply Rumensin-90® (Elanco Animal Health) at 30 g per ton DM.

[5] Formulated to supply Tylan-40® (Elanco Animal Health) at 90 mg per steer daily.

and manure value. Manure credit was assessed as spreading 1 in 4-year rotation to replace phosphorus with the subtraction of hauling expenses and opportunity cost of corn grain and stover removal. The value of manure was calculated using The Beef Feed Nutrient Management Planning Economics (BFNMP$) software using 45% silage-based diet with 20% WDGS. Cattle interest charges were set at 7.5% over the feeding period (days on feed/365) including a $200 deposit. The cost of MDGS was set at 90% the price of corn (DM basis) including 5% shrink. Supplement, including monensin and tylosin, was $300/ ton (DM basis) with 1% shrink applied. Feed interest of 7.5% was applied to half of the total feed amount to average total usage throughout the feeding period. Medicinal and processing charges were $20/head and yardage was charged to $0.50/hd/day. Initial cattle purchase price ($1.8382 / cwt) was calculated to target a net return of $0/ head for cattle on the 14% silage treatment. Returns were calculated as the difference in gross inputs and revenues where values represented profit in dollars per head ($ / hd). Returns were calculated using final body weights with a 63% common dressing percent to calculate live final weight and 5-year average live fat price for Nebraska ($1.3055 / cwt).

Data from the last five years had a correlation (r^2=0.56) between feeder price and fat cattle (Livestock Marketing Information Center; lmic.info). Lower correlation was observed in the last 5 years between feeder price and corn price (r^2= 0.35). However, historically, corn price and feeder calf price have been inversely related. A sensitivity analysis was conducted to assess the changes in returns based on changing corn price and feeder calf price. Corn silage prices floated with the price of corn using the September market price. Corn silage price compared to $3.00, $4.00, and $5.00 corn was $37.18 (per ton DM), $45.00, $52.82, respectively. Feeder calf price was set to break even at 14% corn silage inclusion.

Statistical Analysis

Carcass and performance data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc. Cary, N.C.) where pen was the experimental unit. PROC GLIMMIX of SAS using a multinomial distribution to evaluate distribution differences due to treatment, with block as random to account for overdispersion. Two pens were removed from the analysis after a gate failure allowing cattle to be mixed for an unknown period of time (one rep from 47 -EO and 80 +EO). Treatment differences were declared significant for all statistical analysis at $P \leq 0.05$.

Results

All cattle were fed to a common back fat of 0.51 inches ($P = 0.98$) to ensure equal de-

gree of finish when comparing performance and carcass characteristics. There was no significant interaction ($P \geq 0.60$) between the inclusion of EO in the diet and the inclusion level of silage for all of the carcass adjusted animal performance. There were also no differences interactions observed for carcass characteristics ($P \geq 0.15$).

Essential Oils Effects

There was no significant difference ($P > 0.49$) for the inclusion of essential oils for carcass adjusted animal performance including final body weight, DMI, ADG, and F:G (Table 2). Similarly, there were no differences in HCW or calculated yield grade ($P \leq 0.72$). There was a tendency ($P = 0.13$) for marbling to be slightly greater and for LM area to be greater ($P = 0.04$) for cattle fed no essential oils. However, these differences were small and were not significant enough to yield additional profit.

Corn Silage Effects

There was a significant difference in final body weight and HCW with increasing silage inclusion to have a quadratic effect on body weight ($P < 0.01$; Table 3). Cattle fed 80% corn silage had the greatest final body weight, followed by 47% corn silage, and least for 14% corn silage. There was a quadratic response for ADG and F:G ($P = 0.04$). Cattle fed 14 CS had the greatest ADG followed by 47 CS, and least for 80 CS which had poorer ADG as days on feed increased. Dry matter intake was not significantly different for the 3 silage inclusions ($P = 0.96$). There was a quadratic response ($P < 0.01$) for F:G with cattle fed 14 CS having the lowest F:G, followed by 47 CS, and highest for 80 CS.

There was a linear response for LM area where cattle fed 14 CS had the greatest LM area, 47 CS was intermediate, and least for 80% CS. Marbling score was quadratic with cattle fed 14 CS having the greatest marbling score, 80 CS was intermediate, and 47 CS was least.

Corn Silage Economics

An analysis on the profitability of feeding increasing amounts of corn silage and the economic sensitivity of profitability due to changes in feed costs and finished

Table 2. Main effect of essential oils on carcass adjusted performance on cattle fed three inclusions of corn silage with or without essential oils.

	Treatment[1]			
	+EO	-EO	SEM	F-Test
Pens, n	23	23	-	-
Days of feed	200	200	-	-
Feedlot Performance[2]				
Initial BW, lb	652	652	0.27	0.49
Final BW, lb	1309	1311	4.60	0.74
DMI, lb/d	22.7	22.7	0.12	0.94
ADG, lb/d	3.31	3.32	0.02	0.76
F:G	6.87	6.87	-	0.66
NEm Mcal/lb	0.803	0.798	0.003	0.29
NEg Mcal/lb	0.522	0.517	0.003	0.33
Return, $/h	12.86	12.69	5.06	0.98
Carcass Characteristics				
HCW, lb	835	836	3.00	0.72
LM area, in^2	12.8	13.1	0.08	0.04
12th rib fat, in	0.506	0.506	0.009	0.99
Marbling[3]	453	466	5.90	0.13
Calculated Yield Grade[4]	3.18	3.20	0.024	0.61

[1] EO: essential oils

[2] Calculated on a carcass-adjusted basis using a common dressing percentage (63.8%)

[3] Marbling Score 300 = Slight, 400 = Small, 500 = Modest, etc.

[4] Calculated as 2.5 + (2.5 × 12th rib fat) + (0.2 × 2.0 [KPH]) + (0.0038 × HCW)—(0.32 × LM area).

Table 3. Main effect of corn silage on carcass adjusted performance of cattle fed three inclusions of corn silage.

	Treatment[1]					
	14 CS	47 CS	80 CS	SEM	Linear	Quadratic
Pens, n	16	15	15	-		
Days on feed	168	195	238	-		
Initial BW, lb	652	652	651	0.33	0.22	0.37
Final BW, lb	1265	1290	1374	5.70	< 0.01	< 0.01
DMI, lb/d	22.7	22.7	22.6	0.15	0.85	0.84
ADG, lb/d	3.65	3.27	3.04	0.03	< 0.01	0.04
F:G	6.21	6.93	7.44	-	< 0.01	< 0.01
NEm Mcal/lb	0.848	0.794	0.767	0.004	< 0.01	< 0.01
NEg Mcal/lb	0.558	0.508	0.485	0.003	< 0.01	< 0.01
Return, $/h	-1.09	-6.35	45.76	6.22	<0.01	<0.01
HCW, lb	807	823	877	3.60	< 0.01	< 0.01
LM area, in^2	13.1	12.9	12.8	0.10	0.04	0.61
12th rib fat, in	0.506	0.505	0.508	0.012	0.87	0.90
Marbling[3]	468	447	464	7.30	0.71	0.04
Calculated Yield Grade[4]	3.27	3.04	3.27	0.03	0.88	< 0.01

[1] CS = corn silage.

[2] Calculated on a carcass-adjusted basis using a common dressing percentage (63.8%).

[3] Marbling Score 300 = Slight, 400 = Small, 500 = Modest, etc.

[4] Calculated as 2.5 + (2.5 × 12th rib fat) + (0.2 × 2.0 [KPH]) + (0.0038 × HCW)—(0.32 × LM area).

Table 4. Estimated returns ($ / hd) at varying corn prices for three inclusions of corn silage fed to feedlot cattle.[1]

	Treatment[2]			
Dry Corn Price[3], $ / bu	Feeder Calf Price[4], $ / cwt	14 CS	47 CS	80 CS
3.00	1.9313	0.03	-5.86	42.02
4.00	1.8243	0.01	2.07	50.86
5.00	1.7172	0.06	1.77	59.76

[1] Returns calculated as the difference in gross inputs and revenues. Values represent profit in dollars per head ($ / hd).

Inputs: Total feed costs including processing and shrink. Cattle Interest = [(days on feed / 365) × (feeder price -$200) × 0.75]. Feed Interest = [Total feed costs / 2) × 0.75 × (days on feed / 365)]. Yardage = $ 0.50 / hd / d. Processing = $20 / hd.

Revenue: Final body weights using a 63% common dressing percent to calculate live final weight and 5-year average live fat price for Nebraska ($1.3055 / cwt).

[2] CS = corn silage.

[3] Corn silage prices floated with the price of corn utilizing a September corn price comparison ($-0.20 / bu) compared to $3, $4, and $5 dry corn. The corn silage prices were $37.18 (per ton DM), $45.00, $52.82, respectively.

[4]Initial purchase price was set to break even for 14% corn silage.

steer prices was conducted. The inclusion of EO did not impact returns ($P = 0.98$). Greater returns were projected as corn silage inclusion increased ($P < 0.01$) but the extent of returns was dependent on the price relationships for feed and steer prices. Projected profitability was least (-$6.35/hd) for feeding 47% corn silage but the cattle did not gain as much HCW as past observed years at similar inclusions (*2015 Nebraska Beef Cattle Report*, pp. 66–67; *2018 Nebraska Beef Cattle Report*, pp. 89–91; *2019 Nebraska Beef Cattle Report*, pp. 69–71) . Likely, this was due to longer days on feed relative to the to the cattle's ADG and fat deposition and not enough HCW. The greatest profitability ($ 46.72 / hd) was projected from cattle fed 80% corn silage throughout the feeding period.

Because feed costs heavily influence profitability, differences in returns ($ / hd), based on corn price, were evaluated at the varying inclusions of corn silage (Table 4). As corn price (and corn silage price) increased there was a greater difference in the returns ($ / hd) when cattle were fed 80% corn silage. For example, at $3.00 corn, cattle fed 80% corn silage returned an additional $42.02 per head compared to cattle fed 14% corn silage. Furthermore, when corn was $5.00, returns were even greater ($59.76 / hd) for cattle fed 80% corn silage compared to 14% corn silage. Cattle fed 47% corn silage did not perform as expected. However, returns became greater than feeding at 14% when corn was $4 or above. The same trend held true where increasing corn price led to an increase in returns as $ / hd. These data suggest, as corn becomes more expensive, it becomes more economical to feed corn silage at greater inclusions.

Conclusion

In this study, inclusion of palm oil and fumaric acid (essential oils) did not affect animal performance. The inclusion of EO had no effects on performance, carcass quality or profitability. Greater inclusions of corn silage decreased ADG and F:G but led to greater final body weights when finished to a common back fat thickness. Additionally, 80% inclusion of silage led to increased profitability in dollars per head sold. Feeding corn silage with or without the inclusion of essential oils is economical.

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Effect of Conventional or High Protein Dry Distillers Grains Plus Solubles in Either Dry-Rolled or Steam-Flaked Corn Based Diets on Finishing Performance of Steers

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Summary with Implications

A 2 × 3 factorial finishing study evaluated feeding 0 or 30% high protein distillers grains or conventionally produced distillers in either steam-flaked or dry-rolled corn based diets. Feeding conventional distillers grains in dry rolled corn based diets resulted in improved feed conversion, with no difference between high protein distillers grains as compared to conventional DDGS when included in dry-rolled corn diets. In steam flaked corn-based diets, feeding high protein distillers and conventional distillers tended to increase feed conversion. Feeding conventional distillers or high protein distillers grains resulted in greater DMI and ADG as compared to diets with no distillers inclusion in both dry-rolled and steam-flaked diets. Cattle consuming SFC had lower DMI than DRC, which lead to improved feed conversions as expected. The response to feeding DDGS is different whether replacing dry-rolled corn or steam-flaked corn, but high protein distillers was fairly similar to conventional DDGS.

Introduction

The protein fraction of dry distillers grains plus solubles (DDGS) is partially attributed to the reason cattle have positive performance when fed distillers grains in dry rolled corn (DRC) based diets (*2016 Nebraska Beef Cattle Report*, pp. 124–127). As the ethanol industry has continued to evaluate changes in the process, their ability to fractionate and improve ethanol yields have improved, resulting in a byproduct in which all other nutrients, including protein, become more concentrated. Removal of fiber in the process helps differentiate two distillers products. These new processes will create a byproduct known as high protein DDGS (HiPro), which is approximately 40% crude protein (CP) as compared to conventional DDGS at 30% CP. The value of this new concentrated product and its effect on growth performance as compared to conventional DDGS has not yet been evaluated. Therefore, the objective of this study was to evaluate the feeding value of HiPro as compared to conventional DDGS in beef cattle finishing diets and how the feeding value is affected when fed in either DRC or steam flaked corn (SFC) based diets. The HiPro DDGS is generally targeted at non-ruminant species, therefore, fed as DDGS. In addition, many yards that steam-flake corn, utilize DDGS as a protein source as they tend to be further away (Southern Plains).

Table 1. Diet composition (DM basis) for steers fed dry-rolled or steam-flaked corn with 0 or 30% distillers grains products.

	Treatment[1]					
	CON		DDGS		HiPro	
Ingredient	DRC	SFC	DRC	SFC	DRC	SFC
Dry-Rolled Corn	87.0	-	57.0	-	57.0	-
Steam Flaked Corn	-	87.0	-	57.0	-	57.0
DDGS	-	-	30.0	30.0	-	-
High Protein DDGS	-	-	-	-	30.0	30.0
Sorghum Silage	8.0	8.0	8.0	8.0	8.0	8.0
Dry Supplement[2]	5.0	5.0	5.0	5.0	5.0	5.0
Nutrient Composition[3]						
Crude Protein, %	12.91	12.64	15.22	15.04	17.50	17.33
Starch	62.68	62.85	44.58	44.70	44.13	44.20
NDF, %	14.35	13.44	21.73	21.73	23.39	22.80
ADF, %	7.53	7.25	10.56	10.37	12.97	12.80
Ether Extract, %	3.96	3.10	5.35	4.79	5.17	4.61

[1]Treatments were control (CON), regularly produced DDGS included in the diet at 30% (DDGS) or high protein DDGS included in the diet at 30% (HiPro), fed with either dry rolled corn (DRC) or steam flaked corn (SFC)

[2]Supplement formulated to be fed at 5.0% of diet DM. Supplement consisted of 1.3925% fine ground corn in the CON supplement and 2.7925% fine ground corn in the DDGS and HiPro supplement, and 1.4% urea in the CON supplement and 0% urea in the DDGS and HiPro supplements, 1.50% limestone, 0.125% tallow, 0.30% salt, 0.05% trace mineral package, 0.015% Vitamin A-D-E package as a percentage of the final diet. It was also formulated for 30 g/ton Rumensin®(Elanco Animal Health, DM Basis) and 8.8 g/ton Tylan® (Elanco Animal Health, DM basis).

[3]Based on analyzed nutrients for each ingredient.

Procedures

A 2 × 3 factorial finishing study evaluated three treatments of DDGS in either DRC- or SFC-based finishing diets. The DDGS treatments were no distillers included in the diet (CON), a diet including conventionally produced DDGS (DDGS), and diets including high protein DDGS (HiPro). Corn processing factors included feeding either SFC or DRC as a grain source. Diets are provided in Table 1. A 202-day finishing trial was conducted at the University of Nebraska feedlot near Mead, Nebraska using 360 crossbred steers (initial BW = 635 ± 1.19 lb) sorted into 3 BW blocks and assigned randomly to one of 36 pens (10 steers/pen; 1 repetition heavy block, 4 repetitions medium block and 1 repetition in the light block). All steers were limit-fed a common diet of 50% alfalfa hay and 50%

Table 2. Simple effects of corn processing when fed with no distillers grains, conventional DDGS, or DDGS with greater protein on growth performance and carcass characteristics of finishing cattle

	Treatment[1]							*P*-Value[2]		
	Control		DDGS		HiPro					
Item	DRC	SFC	DRC	SFC	DRC	SFC	SEM	Corn	Distiller	Int
Performance										
Initial BW, lb	636	636	637	636	636	634	1.2	0.26	0.73	0.69
Final BW, lb[3]	1267	1284	1343	1323	1315	1317	10.8	0.94	<0.01	0.22
DMI, lb/day	19.95	18.40	21.54	19.97	21.01	19.88	0.370	<0.01	<0.01	0.80
ADG, lb[3]	3.16	3.24	3.54	3.44	3.39	3.41	0.053	0.99	<0.01	0.22
Feed:Gain	6.37[a]	5.71[c]	6.13[b]	5.85[c]	6.21[ab]	5.85[c]	-	<0.01	0.73	0.02
Carcass Characteristics										
HCW, lb	798	809	846	834	829	830	6.8	0.95	<0.01	0.22
LM Area, in[2]	12.98[a]	13.65[c]	13.56[bc]	13.82[c]	13.41[bc]	13.19[ab]	0.154	0.06	0.02	0.02
Marbling Score[4]	513	505	499	490	533	515	16.7	0.40	0.20	0.95
Backfat Thickness, in	0.48	0.48	0.50	0.53	0.56	0.52	0.022	0.90	0.03	0.37
Yield Grade[5]	2.97	2.81	3.03	2.96	3.16	3.14	0.080	0.19	<0.01	0.65
Liver Abscesses, %[6]	3.57	3.45	1.79	1.72	3.57	0.00	-	-	-	-

[1]Treatments were control (CON), regularly produced DDGS included in the diet at 30% (DDGS) or high protein DDGS included in the diet at 30% (HiPro), fed with either dry rolled corn (DRC) or steam flaked corn (SFC)

[2]Int = *P*-value for the interaction of corn processing method and DGS treatment. Corn = *P*-Value for the main effect of corn processing effect. Distiller = *P*-Value for the main effect of DGS treatment

[3]Calculated from hot carcass weight, adjusted to a common 63% dressing percentage

[4] Marbling Score 400-Small00, 500 = Modest00

[5] Calculated YG (yield grade) = [2.5 + (6.35 × fat thickness, cm) + (0.2 × 2.5% KPH) + (0.0017 × HCW, kg)—(2.06 × LM area, cm^2)]; (USDA, 2016).

[6]Did not converge

SweetBran® at 2% of BW for 5 days prior to trial initiation to minimize gastrointestinal fill. Initial BW was measured on two consecutive days (d0 and d1) and averaged. Steers were fed a supplement that included 30 g/ton DM of Rumensin® (Elanco Animal Health) and 8.8 g/ton of Tylan® (Elanco Animal Health). Cattle were implanted with Revalor-XS® (Merck Animal Health) on d1 of the experiment.

Steam flaked corn was processed to a flake density of 26 lb/bu and was obtained from a nearby feedlot (Raikes Feedlot, Ashland, NE) and obtained approximately every three days. Dried distillers grains plus solubles and the HiPro were obtained from ICM (St. Jospeh, MO) and delivered prior to trial initiation. All diets were fed once daily, with refusals being assessed prior to feeding each morning at approximately 0530. Refusals were subsampled and dried in a 60°C oven for 48 hours to determine DMI. Cattle were slaughtered on d 202 at a commercial abattoir (Greater Omaha, Omaha, NE). Carcass-adjusted final body weight was determined using 63% dressing percentage based on the HCW recorded at the commercial abattoir, the carcass adjusted values were used to determine ADG and feed conversion. Other carcass characteristics included marbling score, 12th rib fat thickness and LM area, which were recorded after a 48-h chill.

Data were analyzed using the MIXED procedures of SAS as a randomized block design with pen as the experimental unit and block as a fixed effect. Liver scores were analyzed using a binominal distribution with the GLIMMIX procedure of SAS. Data were first analyzed for an interaction, and main effects of each factor were analyzed if an interaction was not observed.

Results

There was an interaction ($P = 0.02$) between DGS treatment and corn processing for F:G (Table 2). In DRC-based diets, F:G improved 4.4% with 30% DDGS in the diet. However, in SFC-based diets, feed conversion tended ($P = 0.10$) to increase approximately 2.3% with the inclusion of either DDGS or HiPro in the diet as compared to the CON. Typical response of feeding DDGS in SFC-based diets has been either no change or negative impact on ADG and F:G However, in DRC-based diets, the feeding DDGS is typically positive, with improvements observed in ADG and F:G. In this study, F:G was improved when DDGS were fed in DRC-based diets, but was not imprved in SFC-based diets. There was an interaction ($P = 0.02$) in Longissimus muscle (LM)area, with cattle consuming DRC-CON having the smallest LM area, and SFC DDGS having the greatest LM area, with all other treatments being intermediate. No other interactions ($P > 0.22$) in growth performance or carcass characteristics were observed.

Distillers Grains Plus Solubles Treatment

Including DDGS or HiPro in the diet increased ($P < 0.01$) final body weight, DMI and ADG over the CON treatment (Table 3). Final carcass adjusted body weight increased ($P < 0.01$) 58.4 lb with DDGS and 40.8 lb with HiPro over CON. The greater final carcass adjusted body weight for HiPro and DDGS was in response to the

greater ADG and DMI observed, with cattle consuming DDGS gaining 9% more daily as compared to CON, and 6.3% greater with HiPro, with DDGS tending ($P = 0.10$) to have greater ADG than HiPro. Average daily gain was likely increased due to the increase in DMI, which increased ($P < 0.01$) 8.0% with DDGS and 6.3% for HiPro over the CON treatment. The response to excess protein flowing into the duodenum likely created the growth response, as cattle derived energy from the breakdown of excess amino acids in the small intestine for growth purposes. This has been well documented in previous research (*2016 Nebraska Beef Cattle Report*, pp. 124–127). Marbling score was unaffected by DGS treatment in the diet; however, backfat thickness increased ($P < 0.01$) from 0.48-in for CON to 0.52-in for DDGS and 0.55-in for HiPro, resulting in a greater USDA yield grade for steers fed HiPro.

Table 3. Main effect of DGS treatment on growth performance and carcass characteristics of finishing cattle

	Treatment[1]				
Item	CON	DDGS	HiPro	SEM	*P*-Value[2]
Pens	12	12	12		
Performance					
Initial BW, lb	636	636	635	0.86	0.73
Final BW, lb[3]	1275[a]	1333[b]	1316[ab]	7.95	<0.01
DMI, lb/day	19.17[a]	20.76[b]	20.45[b]	0.262	<0.01
ADG, lb[3]	3.20[a]	3.49[b]	3.40[b]	0.038	<0.01
Carcass Characteristics					
HCW, lb	804[a]	840[b]	829[b]	5.0	<0.01
Marbling Score[4]	509	494	524	12.29	0.20
Backfat Thickness, in	0.48[a]	0.51[ab]	0.54[b]	0.016	0.03
Yield Grade	2.89[a]	3.00[ab]	3.15[b]	0.059	<0.01
Liver Abscesses, %	3.51	1.75	1.79	-	-

[a,b]Means with different superscripts differ ($P < 0.05$).

[1] Treatments were control (CON; no DDGS inclusion), a conventional DDGS included in the diet at 30% (DDGS), and high protein DDGS included in the diet at 30% (HiPro)

[2]*P*-value for the main effect of DGS treatment

[3]Calculated from hot carcass weight, adjusted to a common 63% dressing percentage

[4]Marbling Score 400-Small[00], 500 = Modest[00]

Corn Processing Treatment

Steam flaked corn resulted in a reduction in DMI from 20.8 lb/d for DRC to 19.4 lb/d (Table 4). Despite lower DMI, SFC-based diets had similar ($P = 0.98$) ADG to DRC, averaging 3.36 lb/d for both treatments. This is a typical energetic response observed with SFC compared to DRC, as the energy derived from the more digestible starch in SFC reduces DMI requirements to meet energetic requirements of the animal. Final carcass adjusted body weight and hot carcass weight were not different ($P \geq 0.92$) between SFC and DRC-based treatments. Cattle on the different corn processing treatments were slaughtered at comparable endpoints, as there was no statistical difference ($P = 0.90$) on backfat thickness of 0.51 in of backfat for both treatments, similar marbling ($P = 0.40$) and similar ($P = 0.19$) yield grade scores. Lack of differences in carcass characteristics were attributed to the fact cattle did not have different ADG, which likely resulted in similar carcass deposition, despite lower DMI for SFC based diets.

Table 4. Main effect of corn processing method on growth performance and carcass characteristics

	Treatment[1]			
Item	SFC	DRC	SEM	*P*-value[2]
Pens, n	18	18		
Performance				
Initial BW, lb	636	635	0.73	0.26
Final BW, lb[3]	1309	1308	6.7	0.94
DMI, lb/day	20.83	19.42	0.214	<0.01
ADG, lb[3]	3.36	3.36	0.031	0.99
Carcass Characteristics				
HCW, lb	824	824	4.2	0.95
Marbling Score[4]	515	503	10.4	0.40
Backfat Thickness, in	0.51	0.51	0.014	0.90
Yield Grade	3.05	2.97	0.050	0.19
Liver Abscesses, %	2.976	1.734	-	-

[1]Treatments were steam flaked corn (SFC) or dry rolled corn (DRC) as a grain source in the diet

[2]*P*-Value for the main effect of corn processing treatment

[3]Calculated from hot carcass weight, adjusted to a common 63% dressing percentage

[4]Marbling Score 400 = Small[00], 500 = Modest[00]

Conclusions

Feeding DDGS in DRC-based diets increases ADG and improves F:G. Feeding DDGS in SFC-based diets slightly increases F:G but improves ADG. Feeding HiPro DDGS, despite the higher CP content, resulted in similar performance to cattle consuming conventionally produced DDGS. In SFC-based diets, feeding a higher protein byproduct such as DDGS and HiPro resulted in no improvements in feed conversion, and did not give the same response observed in DRC-based diets.

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Evaluation of Green Grass as a Feed Ingredient in Beef Finishing Rations and Impact on Cattle Performance, Carcass Characteristics, and Fatty Acid Profiles in Meat

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Summary with Implications

A finishing study utilizing 240 crossbred steers (initial BW=750 ± 52 lb.) evaluated the performance, carcass characteristic and fatty acid profiles from finishing steers fed four inclusions (0, 10, 20, 30 % DM basis) of Green Grass. There were no differences in weights, gain or carcass traits. Dry matter intake tended to linearly increase as Green Grass inclusion increased in the diet. Steers fed Green Grass had greater F:G, and steers fed 30 % Green Grass had a lower marbling score. A linear increase in alpha linolenic acid, poly-unsaturated fatty acids, trans-unsaturated unsaturated fatty acids, and omega-3 fatty acids was observed in steak samples from steers fed increasing inclusion of Green Grass. Including up to 20 % inclusion of Green Grass on a DM basis in finishing steer diets appears to have no effect on performance or carcass characteristics. Feeding Green Grass linearly improves omega-3 fatty acid concentration in meat.

Introduction

With human health studies showing benefits from consuming omega-3 fatty acids, there is interest in increasing the amount of omega-3 fatty acids in beef, which typically have small amounts of polyunsaturated fatty acids (PUFAs). Through a process called biohydrogenation, ruminant microbes convert dietary unsaturated fatty acids into more saturated mono-unsaturated fatty acids or completely saturated fatty acids. Research was conducted to determine if increasing omega-3 fatty acids in ruminant diets using a Korean feed product called Green Grass (Sunseo Omega Inc.; Chungcheongbuk-do, Korea) would alter the fatty acid profile in beef, cattle performance, or carcass characteristics.

Procedure

A 203-d finishing study was conducted at the Panhandle Research and Extension Center (PREC) feedlot in Scottsbluff, NE. Two hundred forty crossbred steers (initial BW = 750 ± 52 lb) were utilized. Twelve days prior to the initiation of the trial, steers were penned in groups of 10 and fed a common receiving diet of 45% corn silage, 35% alfalfa hay, 15% WDGS, and 5 % supplement on DM basis. Steers were processed on d-10 with Bovi-Shield Gold 5-way (Zoetis, Parsippany, NJ) Safeguard oral dewormer (Merck Animal Health, Desoto, KS) and given an electronic and panel tag ID ear tags. Steers were limit fed a common diet at 2% of BW for 5 days and weighed for 2 consecutive days at the beginning of the trial to account for gut fill and establish initial BW. Steers were blocked by initial BW (n=3), stratified by day 0 BW, and assigned randomly to pen. Due to an uneven distribution of initial BW, replication 1 (40 hd) was assigned to block 1, replications 2, 3, and 4 (120 hd) were assigned to block 2, and replications 5 and 6 (80 hd) were assigned to block 3. Pens were assigned randomly to 1 of 4 treatments with 10 steers/pen and 6 pens/treatment. Treatments increased inclusion of Green Grass product at 0, 10, 20, and 30 % DM, displacing dry-rolled corn (DRC) in the diet (Table 1). The remaining diet consisted of 15 % WDGS, 20 % corn silage, and 6 % liquid supplement. Two supplements were used, supplement in the control diet supplied extra protein in the form of urea. Supplements were formulated to provide 30 g/ton Rumensin® (Elanco Animal Health, Greenfield, IN) and 8.8 g/ton Tylan® (Elanco Animal Health, Greenfield, IN). Cattle were stepped up to their assigned diets over the course of 24 days starting on day 1 with 5 steps. As step up diets progressed, alfalfa hay and corn silage was displaced by the ratio of dry rolled corn and Green Grass product in each of the treatment diets. Each step did not exceed over a 10% DM displacement of roughage by concentrate.

Cattle were implanted with a Revalor 200 implant (Merck Animal Health, DeSoto, KS), and revaccinated with Express 5-way (Boehringer Ingelheim Vetmedica, Inc., Duluth, GA) and Stand Guard pour-on insecticide (Elanco Animal Health, Greenfield, IN) on day 30. Cattle were harvested at a commercial packing plant (J F O'Neil Packing Co., Omaha, Ne) over 3 harvest days (day 190, 199, 203) where hot carcass weight (HCW), and liver abscess rates were collected. Ribeye area, marbling score, and 12th rib back fat were recorded after a 48 h chill. Final BW, average daily gain (ADG), Feed:Gain (F:G) were calculated from HCW at a 63% dressing percentage. Steak samples were collected by cutting a 1.5" steak from the 5th rib. Steak samples were transported to the University of Nebraska meat lab for fatty acid analysis. Data were analyzed using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC) as a randomized block design. Pen was used as the experimental unit while kill block nested within BW block were included in the model as fixed effects.

Over the course of the feeding period, 4 steers were removed due to death, health or lameness issues. These animals were removed from the statistical analysis by removal from those pen averages. Logistical difficulties resulted in a shortage of Green Grass product to feed at the end of the feeding period. On d 150–176, Green Grass 10, 20, and 30 diets, were dropped to 7.5%, 15%, 22.5% Green Grass inclusion, respectively. On d 177–187, Green Grass 10, 20, and 30 diets, were dropped to 5 %, 7.5%, 15% Green Grass inclusion, respectively. On d 188 through the remainder or the trial, Green Grass 10 and 20 were switched to the control diet, while Green Grass 30 was

dropped to 7.5 % Green Grass inclusion. On day 189 through the remainder of the trial, Green Grass 30 was switched to the control diet.

Results

Performance and Carcass Characteristics

There were no differences in initial body weight (BW), final BW, hot carcass weight (HCW), average daily gain (ADG), calculated yield grade, liver scores, or longissimus muscle (LM) area ($P \geq 0.15$) across all treatments (Table 2.). A linear increase ($P = 0.04$) in DMI was observed for steers fed increasing inclusions of Green Grass. A cubic response was observed, but was generally quadratic ($P = 0.07$) for F:G as Green Grass inclusion increased. As inclusion of Green Grass increased, F:G increased from 6.80 to 7.16. Steers fed Green Grass had similar conversions of 7.19, 7.04, 7.25 for 10, 20, and 30 % Green Grass, respectively. Steers fed 30 % Green Grass had a lower marbling score of 430 (small 30) compared with steers fed 0, 10, 20 % Green Grass which had marbling scores averaging 470 (small 70). Steers fed Green Grass had greater intakes and equivalent ADG resulting in poorer conversions suggesting Green Grass has a lower energy value relative to corn, which was expected. Interestingly, F:G increased but was relatively constant for 10, 20, or 30% inclusion. It is unclear whether altering the Green Grass inclusions from day 150 to 203 impacted performance, but some impacts were expected for the Green Grass replacing energy dense corn during the finishing period.

Fatty Acid Profile Analysis

As inclusion of Green Grass increased in the diet, a linear decrease ($P \leq 0.02$) was observed for C12:0, C14: 1, C15:0, C16:1, C17:0, C17:1, C18:1, C20:3 ω6, and total ω6 (omega-6) in mg/100 g of lean tissue (Table 3, $P < 0.05$). A linear increase ($P \leq 0.01$) was observed for concentrations of C18:1T, C18:2T, C18:2, C13:3ω3, C20:5ω3, and C22:5 in mg/100 g of lean tissue as Green Grass product inclusion in the diet increased. A quadratic effect ($P = 0.06$) was observed for mono-unsaturated fatty acid (MUFA) concentrations with an increase

Table 1. Diet Composition (DM basis) for finishing steers fed 4 inclusions of Green Grass product

	Treatment[1] % Inclusion			
Ingredient	0	10	20	30
Dry-rolled corn	59	49	39	29
Wet Distillers Grains	15	15	15	15
Green Grass[1]	0	10	20	30
Corn Silage	20	20	20	20
Supplement[2]	6	6	6	6
CP, % of sup	46.0	7.0	7.0	7.0
Ca	5.7	5.2	5.2	5.2
P	0.05	0.09	0.09	0.09
Salt	3.1	3.1	3.1	3.1
K	2.6	3.2	3.2	3.2
Vitamin A, IU/lb	10,820	10,820	10,820	10,820
Nutrient Composition[3], %				
DM	54.26	54.28	54.31	54.33
CP, % DM	13.96	13.97	16.31	18.66
ADF, % DM	10.26	12.46	14.65	16.85
Ca, % DM	0.40	0.47	0.56	0.65
P, % DM	0.45	0.51	0.58	0.64
Mg, % DM	0.14	0.17	0.20	0.23
K, % DM	0.81	0.91	0.96	1.02
Na, % DM	0.03	0.04	0.06	0.07
S, % DM	0.17	0.21	0.26	0.30
Fe PPM	65.8	157.2	248.5	339.9
Zinc PPM	26.8	32.0	37.8	43.6
Cu PPM	2.9	6.1	9.2	12.4
Manganese PPM	15.2	22.6	30.1	37.5
Fatty Acid Profile[3], % DM				
C12:0	0.00	0.00	0.00	0.00
C14:0	0.00	0.00	0.00	0.00
C16:0	0.62	0.66	0.70	0.73
C16:1	0.00	0.01	0.01	0.02
C18:0	0.08	0.10	0.13	0.16
C18:1	1.05	1.18	1.31	1.44
C18:2	2.33	2.28	2.22	2.17
C18:3	0.11	0.31	0.52	0.73
C20:0	0.01	0.02	0.02	0.02
C20:1	0.01	0.02	0.02	0.02
C20:5	0.00	0.00	0.01	0.01
C22:0	0.00	0.00	0.01	0.01
C22:6	0.00	0.00	0.01	0.01
C24:0	0.01	0.01	0.01	0.01
Other	0.18	0.22	0.27	0.32
Total FattyAcids	4.40	4.82	5.23	5.65

[1]Differences in dietary treatment were due to Green Grass (Sunseo Omega 3, Chungcheongbuk-do, Korea) inclusion (0 ,10, 20, 30 % of diet DM)

[2]Supplements were formulated to provide 30 g/ton Rumensin (Elanco, Greenfield, IN), 8.8 g/ton Tylan® (Elanco Animal Health, Greenfield, IN), 15500 IU/ lb of dry feed, supplement in diet 0 provided protein in the form of urea

[3]Nutrient Compositions and fatty acid profiles were formulated from ingredient samples

Table 2. Effect of increasing inclusion of Green Grass in cattle performance and carcass characteristics

	Treatment[1]					Contrast		
Item	0	10	20	30	SEM	L[2]	Q[3]	C[4]
Carcass adjusted Performance								
Initial BW, lb	750	750	753	751	1.11	0.91	0.20	0.09
Final BW, lb	1505	1485	1507	1484	10.2	0.16	0.98	0.11
DMI, lb/d	26.2[a]	27.0[ab]	27.1[b]	27.0[b]	0.29	0.04	0.16	0.78
ADG, lb	3.85	3.75	3.85	3.74	0.048	0.14	0.89	0.13
F:G[5]	3.85	7.19[b]	7.04[b]	7.25[b]	-	< 0.01	0.07	0.02
Carcass characteristics								
HCW, lb	948	936	950	935	6.4	0.16	0.96	0.11
LM area, in[2 7]	12.5	12.1	12.4	12.4	0.14	0.85	0.16	0.21
Fat depth, in.	0.73[ab]	0.70[a]	0.78[b]	0.70[a]	0.025	0.88	0.33	0.02
Calculated YG [8]	4.45	4.44	4.62	4.30	0.091	0.43	0.12	0.12
Liver abscess, %	8.97	8.97	12.74	10.89	4.075	0.58	0.83	0.60
Marbling[9]	470[a]	470[a]	480[a]	430[b]	9.75	0.05	0.03	0.35

[1] Differences in dietary treatments were due to Green Grass (Sunseo Omega 3, Chungcheongbuk-do, Korea) inclusion (0, 10, 20, or 30 % of diet DM).

[2] L= P-value for the linear response to Green Grass inclusion

[3] Q= P-value for the quadratic response to Green Grass inclusion

[4] C= P-value for the cubic response to Green Grass inclusion

[5] Analyzed as G:F, reciprocal of F:G

[6]Percent of corn feeding value calculated as percent different in G:F from control divided by incluc

[6] REA (rib eye area in^2)

[8] Calc. YG (calculated yield grade), Calculated as 2.5 + (2.5 × 12th rib fat, in) + (0.2 × 2.5 (KPH, %)) + (.0038 × HCW, lbs.)—(0.32 × REA, in^2)

[9] 400 = Small^0, 500 = Modest^0

[ab] Means in a row with different superscripts differ ($P < 0.05$).

as Green Grass increased in the diet from 0 to 20% inclusion, then a decrease with 30 Green Grass. The concentration of C18:3ω3 and total ω3 (omega-3) fatty acids linearly increased ($P \leq 0.01$), close to 4 times the amount compared to the control in mg/100 g of lean tissue. Poly-unsaturated fatty acids (PUFA), and trans-unsaturated fatty acids (Trans) concentrations also linearly increased ($P \leq 0.01$) in mg/100 g of lean tissue, as Green Grass inclusion increased in the diet. Concentrations of total ω6, and the ratio of ω6:ω3 linearly decreased ($P \leq 0.01$) as Green Grass inclusion increased in the diet. A quadratic response ($P = 0.04$) was observed for total fat % from the proximate analysis, with 10 and 20 Green Grass having greater % fat within lean steak sample at 11.41 % and 11.51 % compared to 0 and 30 Green Grass at 10.96 % and 10.43 % (Table 4.). The percent of moisture in steak samples from the proximate analysis had a quadratic response ($P = 0.02$), with 0 and 30 Green Grass with greater percent moisture in lean steak samples at 68.13% and 68.75 %, compared to 10 and 20 Green Grass at 67.76 % and 67.71 %.The increase in concentration PUFA, total ω3, C18:3ω3 support the hypothesis that increasing the amount of dietary omega-3 fatty acids from feeding Green Grass positively influences fatty acids deposited in the meat, with dramatic increases in ω3 (omega-3) fatty acids.

Conclusion

Steers fed Green Grass had greater intakes and equivalent ADG compared to control cattle resulting in poorer feed conversion; however, other cattle performance parameters and carcass characteristics were not affected as Green Grass inclusion in the diet increased up to 30 % on DM basis. Steers fed 30 % Green Grass had lower marbling scores; however, they had higher concentrations of PUFA, total ω3, and C18:3ω3. Displacing corn up to 30 % on DM basis with Green Grass product does not affect gain, and improves the PUFA, total ω3, and C18:3ω3 concentrations in the meat. More research is needed to determine the energy content and digestibility of Green Grass, and the significance of the change in ω3 fatty acid concentrations in the steaks.

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Table 3. Fatty acid profile of steak samples collected at the 5th rib from steers fed increasing inclusion of Green Grass product in mg/100g of lean tissue (DM basis)

	Treatment[1]					Contrast		
Fatty acid	0	10	20	30	SEM	L	Q	C
C10:0	9.30	7.77	5.93	5.66	1.222	0.03	0.62	0.74
C12:0	5.22[a]	3.89[ab]	2.87[b]	1.80[b]	0.786	< 0.01	0.87	0.93
C14:0	342	361	343	328	11.8	0.28	0.16	0.46
C14:1	103[a]	106[a]	89.8[b]	89.1[b]	4.15	< 0.01	0.64	0.08
C15:0	43.91[ab]	47.51[a]	40.57[b]	37.24[b]	2.345	0.02	0.16	0.20
C15:1	139	162	156	140	8.4	0.95	0.03	0.06
C16:0	2796	2892	2915	2680	83.2	0.39	0.63	0.63
C16:1T	25.90	30.95	23.36	35.78	6.165	0.43	0.56	0.25
C16:1	374[a]	348[a]	345[a]	299[b]	11.7	< 0.01	0.39	0.22
C17:0	117[a]	127[a]	113[ab]	98.7[b]	5.667	< 0.01	0.05	0.40
C17:1	141[ab]	155[b]	127[ab]	116[a]	9.7	< 0.02	0.20	0.18
C18:0	1525	1631	1647	1494	61.2	0.79	0.05	0.77
C18:1T	302[a]	392[b]	425[b]	414[b]	20.4	< 0.01	0.02	0.88
C18:1	4099[a]	4059[a]	4130[a]	3555[b]	139.2	0.02	0.07	0.24
C18:1V	185	181	203	182	9.8	0.74	0.40	0.14
C18:2T	47.00[a]	48.25[a]	52.04[a]	62.80[b]	3.349	< 0.01	0.17	0.77
C19:0	13.57[a]	23.71[a]	31.90[b]	24.30[ab]	3.638	0.02	0.03	0.41
C18:2	355[a]	449[b]	484[bc]	508[c]	14.5	< 0.01	0.03	0.48
C18:3ω6	10.53[a]	4.14[b]	4.57[b]	3.63[b]	2.042	0.04	0.20	0.38
C18:3ω3[2]	21.71[a]	53.04[b]	68.29[c]	87.77[d]	3.819	<0.01	0.14	0.25
C20:0	11.78	17.47	12.08	3.75	5.943	0.28	0.25	0.76
C20:1	47.46	50.80	49.02	51.53	3.980	0.57	0.92	0.60
C20:2	35.35[a]	41.74[a]	23.27[b]	9.29[c]	4.371	< 0.01	0.03	0.15
C20:3ω6	26.27[a]	24.05[ab]	21.63[bc]	19.71[c]	1.209	< 0.01	0.90	0.90
C20:3ω3	1.73	1.47	1.65	2.19	1.325	0.79	0.77	0.99
C20:4ω3	0.0	0.0	0.0	0.0	-	-	-	-
C20:4ω6	72.88[a]	79.21[a]	68.84[ab]	61.07[b]	3.125	< 0.01	0.04	0.19
C20:5ω3	0.0[a]	1.87[b]	1.99[b]	7.12[c]	0.511	< 0.01	< 0.01	< 0.01
C22:0	1.47	1.95	1.13	0.00	0.659	0.09	0.24	0.74
C22:1	10.79	3.96	0.00	3.31	2.970	0.06	0.11	0.74
C22:2	0.00	0.00	0.26	0.00	0.124	0.64	0.30	0.17
C22:4	5.59[a]	5.36[a]	3.43[ab]	0.0[b]	1.200	< 0.01	0.20	0.97
C22:5	9.33[a]	18.46[b]	20.48[bc]	24.15[c]	1.511	< 0.01	0.09	0.21
C22:6	0.30	1.14	4.22	5.09	1.410	0.01	0.99	0.49
C23:0	0.99	0.55	0.00	1.68	0.691	0.63	0.14	0.46
C24:1	17.49[a]	6.56[b]	2.06[c]	2.39[c]	1.244	< 0.01	< 0.01	0.78
TOTAL	10,894	11,335	11,417	10,352	336.7	0.32	0.04	0.61
Other	64.00	75.02	90.91	79.21	8.993	0.14	0.22	0.43
SFA[3]	4854	5105	5102	4659	155	0.41	0.04	0.79
UFA[4]	6040	6230	6315	5693	186	0.27	0.04	0.48
SFA:UFA	87.88	93.49	93.19	85.23	2.987	0.54	0.04	0.90
MUFA[5]	5440	5483	5544	4891	175.5	0.06	0.06	0.36

Table 3. Continued

	Treatment[1]					Contrast		
Fatty acid	0	10	20	30	SEM	L	Q	C
PUFA[6]	600[a]	747[b]	772[b]	803[c]	22.1	< 0.01	0.02	0.21
Trans[7]	376[a]	470[b]	496[b]	510[b]	25.0	< 0.01	0.13	0.62
ω6[8]	112[a]	110[a]	97.2[ab]	86.4[b]	5.09	< 0.01	0.36	0.54
ω3[9]	24.19[a]	56.99[b]	73.01[c]	97.30[d]	4.320	< 0.01	0.34	0.22
ω6: ω3	5.64[a]	2.28[b]	1.55[b]	0.93[b]	0.552	< 0.01	0.02	0.32

[1]Differences in dietary treatment were due to Green Grass (Sunseo Omega 3, Chungcheongbuk-do, Korea) inclusion (0 ,10, 20, 30 % of diet DM)

Note: [2]C18:3ω3= Alpha linolenic acid, [3]SFA = saturated fatty acids, [4]UFA=unsaturated fatty acids, [5]MUFA = monounsaturated fatty acids, [6]PUFA = polyunsaturated fatty acids, [7] Trans= Trans-unsaturated fatty acids, [8] ω6= total omega 6 fatty acids, [9] ω3=total omega-3 fatty acids

[abcd] Within row, means without a common superscript differ ($P < 0.05$)

Table 4. Proximate analysis of lean steak samples from steers fed increasing inclusion of Green Grass product

	Treatment[1]					Contrast		
Item	0	10	20	30	SEM	L[2]	Q[3]	C[4]
Fat, %	10.96[ab]	11.41[ab]	11.51[a]	10.43[b]	0.340	0.34	0.04	0.60
Moisture, %	68.13[ab]	67.76[a]	67.71[a]	68.75[b]	0.260	0.20	0.02	0.57

[1]Differences in dietary treatment were due to Green Grass inclusion (0 ,10, 20, 30 % of diet DM)

[2] L= P-value for the linear response to Green Grass inclusion

[3] Q= P-value for the quadratic response to Green Grass inclusion

[4] C= P-value for the cubic response to Green Grass inclusion

Nutrient Digestibility of Condensed Algal Residue Solubles in Beef Cattle Fishing Diets

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Summary with Implications

Condensed algal residue solubles (CARS) were evaluated in finishing cattle diets. Six treatments were evaluated (2 × 3 factorial arrangement), CARS inclusion in the diet at 0, 5, or 10% of diet dry matter with 0 or 20% wet distillers grains. The remainder of the diets consisted of 57.5–87.5% dry rolled corn, 7.5% sorghum silage and 5% supplement. Increasing wet distillers grains in the diet had no effect on dry matter and organic matter intake but decreased dry matter and organic matter digestibility. Increasing CARS inclusion in the diet resulted in lower dry matter and organic matter intake with no effect on dry matter and organic matter digestibility. Replacing up to 10% dry rolled corn with CARS in diets with or without wet distillers grains had little effect on digestibility of finishing beef cattle diets.

Introduction

Feeding algae to animals is not a new idea, as algae has been used in animal diets dating back 60 years; however, until recently, heterotrophic algae have not been available. A condensed algal residue solubles (CARS; Veraferm, Veramaris, Delft, The Netherlands) product is being commercially produced (Blair, NE) from heterotrophic algae as a co-product from producing n-3 fatty acids for aquaculture and the pet food industry. This CARS product is available for use in the cattle industry. CARS was fed in a 100 d safety study where cattle fed between 2.5 and 5% CARS had similar HCW, ADG, and DMI, with lower F:G than control cattle (*2019 Nebraska Beef Cattle Report*, pp. 82–84). CARS now has expert-affirmed GRAS (generally recognized as safe) status, but this trial was completed prior to that, thus all cattle were euthanized and composted at the completion of the trial. With limited research done on this product, the objective of this study was to evaluate the digestibility of CARS at different inclusion levels, with and without wet distillers grains, in finishing cattle diets.

Table 1. Diet composition (DM basis) for finishing cattle fed 3 levels of CARS with 0 or 20% WDGS

	0 CARS[1]		5 CARS[1]		10 CARS[1]	
Item, %	0 WDGS[2]	20 WDGS[2]	0 WDGS[2]	20 WDGS[2]	0 WDGS[2]	20 WDGS[2]
WDGS	-	20	-	20	-	20
CARS	-	-	5	5	10	10
DRC	87.5	67.5	82.5	62.5	77.5	57.5
Sorghum Silage	7.5	7.5	7.5	7.5	7.5	7.5
Supplement[3]	5.0	5.0	5.0	5.0	5.0	5.0
FGC	1.264	2.824	1.844	3.134	2.404	3.134
Limestone	1.690	1.670	1.690	1.660	1.680	1.660
Tallow	0.125	0.125	0.125	0.125	0.125	0.125
Urea	1.540	-	1.260	-	0.710	-
Salt	0.300	0.300	-	-	-	-
Trace mineral	0.050	0.050	0.050	0.05	0.050	0.050
Rumensin	0.016	0.016	0.016	0.016	0.016	0.016
Vitamin ADE	0.015	0.015	0.015	0.015	0.015	0.015
Nutrient Composition, %						
DM	77.0	59.0	73.0	56.6	69.4	54.6
OM, % DM	98.1	97.3	96.3	95.5	94.5	93.7
CP, % DM	12.81	12.98	12.83	13.77	12.10	14.53
Fat, % DM	3.72	5.19	4.26	5.69	4.77	6.18
Na, % DM	0.15	0.18	0.68	0.71	1.33	1.36
S, % DM	0.11	0.22	0.15	0.26	0.19	0.30

[1] Treatment, % CARS, (DM basis); CARS = condensed algal residue solubles

[2] Treatment, % WDGS, (DM Basis); WDGS = wet distillers grains plus solubles

[3] Supplement targeted Rumensin at 330 mg/animal daily; Elanco, Greenfield, IN) and Vitamin A-D-E premix contained 1500 IU vitamin A, 3000 IU vitamin D, and 3.7 IU vitamin E per g.

Procedure

A digestibility study was conducted utilizing 6 steers in a 6 × 6 Latin square design to evaluate the effects of inclusion of condensed algal residue solubles (CARS). Treatments were set up as a 2 × 3 factorial arrangement with 2 levels of wet distillers grains (0 or 20% WDGS), and 3 levels of CARS (0, 5, and 10% on a DM basis). The remainder of the diets consisted of 57.5 to 87.5% dry rolled corn, 7.5% sorghum silage and 5% supplement on a DM basis (Table 1). Supplement consisted of limestone, vitamin A-D-E, beef trace minerals, urea in the 0% WDGS diets, and fine ground corn as the carrier.

Cattle were fed *ad libitum* with feed delivered twice daily. Each period was 21 days in length consisting of 16 d adaption and a 5 d collection period. On d 10–21 of

Table 2. Main effects of condensed algal residue solubles (CARS) inclusion on digestibility of cattle finishing diets

	TREATMENT, % CARS				*P*-value		Contrast	
Item	0	5	10	SEM	CARS	CARS*WDGS	Lin	Quad
DM								
Intake, lb	18.4[a]	17.9[a]	16.0[b]	0.69	0.03	0.41	0.01	0.39
Digestibility, %	75.7	74.2	73.9	1.41	0.52	0.82	0.29	0.67
OM								
Intake, lb	18.0[a]	16.9[ab]	15.1[b]	0.69	0.01	0.55	< 0.01	0.63
Digestibility, %	77.3	75.8	76.0	1.29	0.57	0.87	0.41	0.51
NDF								
Intake, lb	4.4[a]	4.1[a]	3.6[b]	0.16	< 0.01	0.39	< 0.01	0.62
Digestibility[1], %	41.1	48.6	38.9	1.97	0.01	< 0.01	0.65	< 0.01

[a-b] Values within rows with similar superscript are not different ($P > 0.05$)

[1]NDFD interaction of CARS level by distillers grain inclusion shown in Figure 1

Table 3. Main effects of wet distillers grains plus solubles (WDGS) inclusion on digestibility of cattle finishing diets

	WDGS			*P*-Value	
Item	0 %	20 %	SEM	WDGS	CARS*WDGS
DM					
Intake	16.9	18.0	0.60	0.16	0.41
Digestibility, %	76.7[a]	72.5[b]	1.25	< 0.01	0.82
OM					
Intake, lb	16.2	17.2	0.59	0.17	0.55
Digestibility, %	78.2[a]	74.6[b]	1.14	< 0.01	0.87
NDF					
Intake, lb	3.5[a]	4.6[b]	0.14	< 0.01	0.39
Digestibility[1], %	42.1	44.3	1.61	0.34	< 0.01

[a-b] Values within rows with similar superscript are not different ($P > 0.05$)

[1]NDFD interaction of CARS level by distillers grain inclusion shown in Figure 1

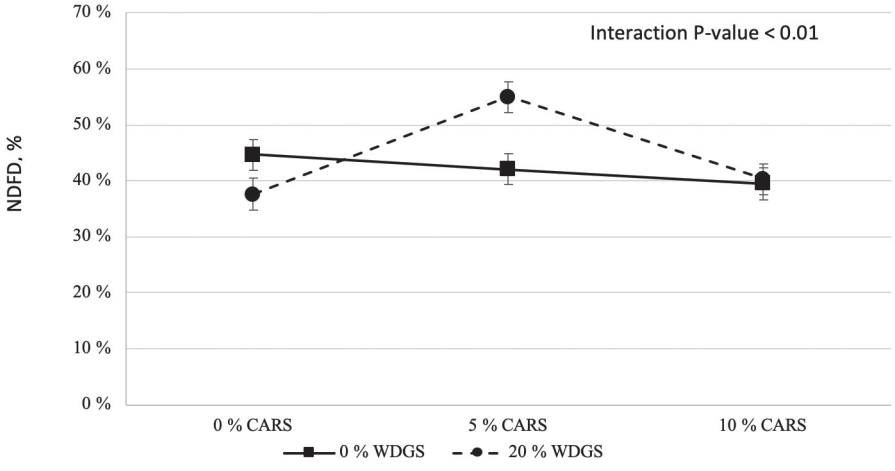

Figure 1. NDF Digestibility interaction on condensed algal residue solubles (CARS) and distillers inclusion (WDGS).

each period, 5 g of TiO_2 in a 100 ml mixture of distillers solubles was top dressed on the feed at each feeding for a total of 10 g of TiO_2 dosed daily. On d 16–21 fecal grab samples were collected 4 times/d and composited into 1 d samples. Feed samples and fecal grab samples were freeze dried, ground through a 2-mm screen, composited, and analyzed for neutral detergent fiber (NDF), organic matter (OM), and TiO_2 concentration for total fecal DM output. Digestibility data were analyzed as a Latin Square using the mixed procedure of SAS (SAS Inst., Cary, N.C.) with period, WDGS inclusion, CARS inclusion, and the interaction between WDGS and CARS as fixed effects and steer as a random effect.

Results

For the main effect of CARS, a linear decrease was observed for DM intake (DMI; $P = 0.01$; Table 2), with 0 and 5% CARS having similar DMI at 18.4 and 17.9 lbs respectively, and 10% CARS having lower DMI at 16.0 lbs. Similarly, a linear decrease was observed for both OM intake (OMI) and NDF intake (NDFI; $P \leq 0.01$) as CARS increased from 0 to 10% in the diet. CARS has a high Na content, which may limit intake and affect DM digestibility (DMD) at higher inclusions. There were no statistical differences observed for DMD ($P = 0.29$) however we observed a numerical difference of 1.8 percentage units between the 0 CARS and 10 CARS treatments. Similarly, no significant difference was observed for OM digestibility (OMD; $P = 0.41$), however we observed a numerical reduction of 1.3

percentage units as CARS increased from 0% to 10% in the diet. The only statistical difference between steers fed 0% CARS and 5% CARS was NDF digestibility (NDFD; $P = 0.01$) suggesting that CARS has a similar feeding value as dry rolled corn at 5% inclusion.

For the main effect of WDGS, no differences were observed for DMI or OMI ($P \geq 0.16$; Table 3). Steers fed 0% WDGS had greater DMD ($P < 0.01$) at 76.7% compared to 72.5% for steers fed 20% WDGS. Similarly, steers fed 0% WDGS had greater OMD ($P < 0.01$) at 78.2%, compared to 74.6% for steers fed 20% WDGS. Steers fed 20% WDGS had greater NDF intake at 4.6 lbs per day ($P < 0.01$) compared to 3.5 lbs for steers fed 0% WDGS.

A CARS by WDGS inclusion interaction was observed for NDFD ($P < 0.01$). Steers fed 5% CARS and 20% WDGS had a NDFD of 55.0%, which was greater than the rest of the treatment diets that ranged from 39.5 to 44.7% NDFD (Figure 1). Due to the soluble nature and the low NDF content of CARS, it is difficult to get good estimates of NDF intake and NDFD. No other interactions were observed for CARS by distillers grain inclusion ($P \geq 0.39$).

Conclusion

Results indicate decreased DMI and OMI as CARS inclusion increased in the diet, however, this had no effect on DMD or OMD. This would agree with performance results when cattle were fed 0, 2.5, 5, and 7.5% CARS (*2019 Nebraska Beef Cattle Report*, pp. 82–84). Replacing up to 5% corn with CARS in finishing cattle diets with wet distillers grains at 0 or 20% diet DM, appears to have little effect on DMI, DMD, OMI or OMD. Further research is needed to determine the optimal inclusion of CARS in finishing cattle diets on performance, carcass characteristics, and fatty acid profiles of beef.

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Chopped Sugar Beets for Growing and Finishing Cattle

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Summary with Implications

Crossbred steers (n=270; 645 lb, ± 3 lb) were used in a 2 × 3 factorial treatment design in a growing (54 d) and finishing study (130 d). The factors were 0 or 44% sugar beets (dry matter basis) in place of dry rolled corn, during the growing phase and 0, 15, or 30% sugar beets during the finishing phase. Daily gain was not different for the growing treatments but the calves on the 44% sugar beet treatment had less dry matter intake than those on the 0% sugar beet treatment, making them 5.5% more efficient. However, during the finishing phase, the steers on the 0% sugar beet treatment had greater daily gain than those on the 44% sugar beet treatment. Related to the beet inclusion during finishing, the 0% sugar beet treatment and the 15% had similar gain and feed efficiency, which was greater than the 30% sugar beet treatment. Hot carcass weight, back fat, and yield grade were greatest for the 0%, followed by 15%, and with 30% sugar beets having the least. Including sugar beets in a growing ration could increase feed efficiency by decreasing dry matter intake with similar gain. Including sugar beets in a finishing diet will likely not result in similar performance or carcass characteristics to a dry-rolled corn based diet.

Introduction

Sugar beet production is a major economic driver in the Nebraska Panhandle, generating $165 million annually to the economy. However, situations arise when the sugar beets produced cannot be used for human consumption, because either quality control standards were not met, or government regulations impede sugar production from beets. When these situations arise, it would be useful to know how best to incorporate the rejected beets into beef cattle diets; and what value to assess relative to beets used for human consumption.

Therefore, the objectives of this study was to determine the impacts of feeding complete sugar beets as a replacement to dry rolled corn in growing and finishing diets on performance, and carcass characteristics.

Table 1. Growing and finishing cattle diets containing chopped complete sugar beets

	% Sugar beets, dry matter basis	
Growing Diet	0	44
Sugar beet mix[1]	0	61
Wheat straw	17	0
Corn	39	0
Alfalfa	18	13
WDGS[2]	21	21
Supplement	5	5

	% Sugar beets, dry matter basis		
Finishing Diet	0	15	30
Sugar beet mix[1]	0	21	42
Wheat straw	8	0	0
Corn	61	48	31
Alfalfa	6	6	0
WDGS[2]	20	20	22
Supplement	5	5	5

[1]Sugar beet mix is 72% sugar beets, 28% straw on a dry matter basis (stored 3 weeks prior to trial initiation)

[2]WDGS = wet distillers grains with solubles

Procedure

Sugar beets were chopped and packed with straw (90% beets 10% straw, as is basis) to prevent sugar loss three weeks prior to trial initiation. Crossbred steers (n=270; 645 lb) were purchased from local ranches and vaccinated for respiratory and clostridial diseases and given an anthelmintic shortly after arrival at the Panhandle Research and Extension Center Feedlot. Cattle were weighed two consecutive days after being limit fed at 2% body weight for 5 days. The average was the starting weight for the growing trial. Cattle were administered a growth implant at the initiation of the growing phase and again midway through the finishing phase. Cattle were blocked into two weight blocks, assigned to pens, which were assigned to both growing and finishing treatments (5 pens/trt). The treatment design was a 2 × 3 factorial, with growing treatments being the first factor (0 or 44% sugar beets on a dry matter basis in the diet) (GROW 0 and GROW 44, respectively); and the other factor being the finishing treatments with 0, 15, or 30% sugar beets in the finishing diet replacing dry rolled corn (FIN 0, FIN 15, and FIN 30, respectively). Diets are presented in Table 1. Cattle were weighed at the conclusion of the 54-d growing phase two consecutive days after a five-day limit feeding period. This served as the ending body weight for the growing trial and the initial body weight for the finishing period. Growing body weight, daily gain, feed intake, and feed efficiency

were evaluated. After the 130 d finishing period, the cattle were weighed on a pen scale and harvested at a commercial abattoir in Ft. Morgan, CO where hot carcass weight was collected on the day of slaughter and longissimus muscle (LM) area, marbling score and back fat were recorded after a 48 hr chill. Final body weight, daily gain, and feed efficiency were calculated based on hot carcass weight and a 63% dress.

The trial was analyzed as a randomized complete block design with pen as the experimental unit. Treatment design was a 2 × 3 factorial.

Results

Initial weight, final weight, and daily gain for the growing period were not different ($P > 0.20$). Dry matter intake was less for GROW 44 than GROW 0, resulting in a tendency for feed efficiency to be greater for GROW 44 (Table 2). This resulted in the sugar beets having 5.5% increased efficiency over corn giving it 112% the feeding value of corn in a growing diet.

The growing treatments impacted finishing performance. There was an interaction for dry matter intake (DMI) and marbling ($P < 0.04$) (Table 3). Dry matter intake was similar across FIN 0,15, and 30 for GROW 0, but decreased linearly for GROW 44. Marbling, although choice for all treatments, was greater for FIN 0 while FIN 15 and FIN 30 were not different at GROW 0. For GROW 44, FIN 0 and FIN 15 had greater marbling than FIN 30 ($P < 0.03$).

Main effects are presented in Table 4. Final body weight and daily gain were greater for the GROW 0 than for GROW 44. During the finishing period, the cattle fed FIN 0 had the greatest final body weight, followed by FIN 15, with the FIN 30 having the lightest weight. Average daily gain was not different for FIN 0 and FIN 15, which were greater than FIN 30. Dry matter intake was greatest for the FIN 0 while FIN 15 and FIN 30 were not different ($P < 0.05$). Feed efficiency was not different for FIN 0 and FIN 15, which were greater than the FIN 30 ($P < 0.05$) (Table 4).

Hot carcass weight, back fat, and yield grade were greater for GROW 0 than GROW 44 (Table 4; $P < 0.05$). Hot carcass weight, back fat, and yield grade all decreased as sugar beets increased from 0% to 30% on the finishing treatments. Analyses of diet composites indicated FIN 0, FIN 15, and FIN 30 contained 21.9, 27.7, and 37.0% NDF respectively. This is due to the increasing amount of straw fed and likely contributed to the differences in performance across the finishing treatments. Chopping and mixing fresh sugar beets daily could eliminate this challenge. However, storing whole sugar beets through the winter is challenging and sugar loss does occur when beets begin to rot (*2018 Nebraska Beef Cattle Report*, pp. 28–29).

Table 2. Growing performance of calves fed a growing diet with or without sugar beets.

	0% Sugar Beets	44% Sugar Beets (DM)	SE	*P* value
Initial Weight	647	642	29.7	0.22
Ending Weight	816	808	26.0	0.20
Daily gain, 54 d	3.12	3.08	0.08	0.65
Dry matter intake	19.2	18.0	0.20	<0.0001
Feed:gain	6.20	5.87		0.063

Table 3. Simple effects of dry matter intake and marbling of steers fed 0 or 44% sugar beets on a growing trial and 0, 15 or 30% sugar beets on a finishing trial.

	Growing Treatment, % Sugar Beets, DM Basis							
	0	0	0	44	44	44		
	Finishing Treatment, % Sugar Beets, DM Basis							
	0	15	30	0	15	30	SE	Interaction
DMI[1]	26.8[ab]	25.8[ad]	26.0[ab]	26.9[b]	26.0[bd]	24.4[c]	0.37	0.04
Marbling[2]	512[a]	460[bd]	454[b]	490[ad]	497[a]	475[bc]	11.2	0.04

[1]DMI=dry matter intake

[2]Marbling score 400=low choice, 700=prime

[abcd]Superscripts which differ within a row are significant ($P < 0.05$).

Conclusion

Including sugar beets in a growing ration could increase feed efficiency by decreasing dry matter intake with similar gain. Including sugar beets over 15% in a finishing diet will likely not result in similar performance or carcass characteristics to a corn based diet.

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Table 4. Main Effects of finishing performance and carcass characteristics of steers fed 0 or 44% sugar beets on a growing trial and 0, 15 or 30% sugar beets on a finishing trial.

	Growing Treatment			Finishing Treatment					
	% Sugar Beets, DM basis			% Sugar Beets, DM basis					
lbs	0	44	SE	0	15	30	SE	Linear	Quad
Initial BW	815	808	3.7	814	810	811	4.5	0.68	0.68
Final Live BW	1304[a]	1276[b]	5.9	1325[a]	1302[b]	1243[c]	7.1	<0.01	0.05
Carcass Adj. Final BW	1295[a]	1267[b]	8.1	1341[a]	1282[b]	1220[c]	9.8	<0.01	0.84
Daily Gain	3.69[a]	3.53[b]	0.06	4.06[a]	3.64[b]	3.15[c]	0.07	<0.01	0.68
Dry matter Intake	26.2	25.7	0.22	26.9[a]	25.9[b]	25.2[b]	0.26	<0.01	0.74
Feed:gain	7.17	7.37		6.65[a]	7.14[b]	8.03[c]		<0.01	0.15
Hot Carcass Weight	816[a]	798[b]	5.1	845[a]	808[b]	768[c]	6.2	<0.01	0.82
Dressing %	62.6	62.5	0.38	63.8[a]	62.1[b]	61.8[b]	0.47	<0.007	0.22
Back fat, inches	0.49[a]	0.45[b]	0.01	0.53[a]	0.48[b]	0.40[c]	0.02	<0.01	0.39
Ribeye Area, inches	13.8	13.8	0.11	13.9	13.8	13.6	0.13	0.12	0.93
Yield grade	2.8[a]	2.7[b]	0.04	3.0[a]	2.8[b]	2.5[c]	0.05	<0.01	0.48
Marbling[1]	476	487	6.5	501[a]	479[b]	465[b]	11.2	<0.01	0.68

[abc]Superscripts which differ within a row in growing treatment are significant ($P < 0.05$).

[abc]Superscripts which differ within a row in finishing treatment are significant ($P < 0.05$).

[1]Marbling 400=low choice, 700=prime

Comparing SHREDLAGE® and Conventional Silage as a Roughage Component in Steam-Flaked Corn Diets for Finishing Cattle

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Summary with Implications

A study was conducted at the Panhandle Research and Extension Center feedlot evaluating SHREDLAGE® processed at 26.5 mm and 1 mm gap; by CLAAS, to conventional chopped corn silage at 13 mm with a standard CLAAS processor set to 1 mm, as a roughage source at two inclusions for cattle fed steam-flaked corn based finishing diets. Yearling steers (930 lb) were fed finishing diets containing 9 or 14% (dry matter basis) conventionally chopped corn silage or corn SHREDLAGE® in a 2 × 2 factorial treatment arrangement. Cattle fed rations containing SHREDLAGE had greater final body weight, hot carcass weight, average daily gain, and less dry matter intake, which resulted in better conversions (P < 0.05) than cattle fed conventionally chopped corn silage. Feed efficiency was improved when 9% silage was fed compared to 14% silage. Feeding SHREDLAGE and reducing the amount of roughage fed resulted in improved hot carcass weight, daily gain, and efficiency compared with feeding traditional silage at 14% inclusion. These results suggest shredding silage, resulting in larger particles, can improve performance at lower inclusions compared to traditionally chopped silage.

Introduction

Roughage is a necessary component in finishing diets for beef cattle as it helps maintain rumen function and reduces digestive upset. However, roughages are bulky, somewhat expensive for feedlots to acquire and store, and increase the volume in the feed truck, which increases the number of loads it takes to feed cattle thereby increasing the cost of feeding. Therefore, if the amount of roughage fed could be reduced without negatively impacting feedlot performance, efficiency of production could be improved.

Steam-flaking corn improves the utilization of the energy in corn, but can also make cattle more susceptible to digestive upset due to the rapid digestion of starch in the rumen compared to dry rolling corn. Larger particles of roughage might help alleviate rumen digestive disorders. Therefore, a study was conducted at the Panhandle Research and Extension Center feedlot evaluating SHREDLAGE at 26.5 mm and 1 mm gap SHREDLAGE processor, (CLAAS), to conventional chopped corn silage at 13 mm with a standard CLAAS processor set to 1 mm, as a roughage source at two inclusions for cattle fed steam-flaked corn based finishing diets.

Procedure

The corn silages used in this study were produced at the Panhandle Research and Extension Center (PREC). The traditional silage as well as the SHREDLAGE® were harvested and stored in 7ft silage bags on September 9 and 10. All the corn silage material was harvested from the same flood irrigated field. The conventionally chopped material was harvested at a length of 13mm with a standard corn processor set at 1 mm gap. The shredded material was chopped at a length 26.5mm with the corn processor set at 1 mm gap. Silage was ensiled over 60 days prior to trial initiation. The dry matter of both silages averaged 35–37% for the duration of the trial.

Crossbred steers (n=288; initial body weight 930 lb) were utilized in a 128 d feeding trial to evaluate silage processed as SHREDLAGE® or traditional corn silage at 9% or 14% inclusion on a dry matter (DM) basis in steam-flaked corn diets (Table 1). Treatments were set up in a 2 × 2 factorial arrangement with processing method and silage inclusion as the factors. Cattle were vaccinated against respiratory and clostridial pathogens and treated for parasites prior to trial initiation. Cattle were implanted with Revalor 200 on day 23. At the conclusion of the trial, cattle were weighed on a pen scale and harvested at a commercial abattoir in Ft. Morgan, CO where hot carcass weight (HCW) and liver scores were collected on the day of slaughter and longissimus muscle area (LM), marbling score and back fat were recorded after a 48 hr chill. Final body weight (BW), average daily gain (ADG), and feed efficiency (F:G) were calculated based on HCW and a dressing of 63%.

Data were analyzed considering pen as the experimental unit. The model was a randomized complete block design. Cattle were blocked by weight and each block contained one replicate of treatments. Treatments were managed as a 2 × 2 factorial arrangement. This was done using the General Linear Model software of SAS. Liver damage was evaluated as frequency data using animal as the experimental unit (Chi Square test) as well as by transforming liver scores for pen mean tests analyzed using the same statistical methods applied to body weight tests.

Results

There were no interactions so main effects are presented. Cattle fed rations containing SHREDLAGE had greater final BW, ADG, and less DMI, which resulted in lower F:G ($P < 0.05$) than cattle fed conventionally chopped corn silage (Table 2). Hot carcass weight was greater for the SHREDLAGE than the conventional corn silage ($P < 0.02$) while backfat, marbling, yield grade, and liver scores were not significant ($P > 0.20$).

There was a tendency for the 9% roughage inclusion to improve final BW ($P = 0.06$) and ADG ($P = 0.09$) while F:G was improved ($P = .04$) Dry matter intake was not different ($P > 0.20$). There was a tendency for hot carcass weight and marbling ($P > 0.07$) to be greater for the 9% inclusion level

Table 1. Finishing diets for steers fed either SHREDLAGE® or traditional corn silage at 9 or 14% of diet dry matter

Ingredient, % DM	14% corn silage or SHREDLAGE®	9% corn silage or SHREDLAGE®
Corn silage	14.0	9.0
Steam Flaked Corn	66.0	71.0
WDGS	15.0	15.0
Supplement[a]	5.0	5.0

[a] custom formulated suspension, formulated to supply 360 mg/hd monensin, and vitamins and minerals to meet or exceed NRC requirements for finishing steers.

Table 2. Main effects for performance and carcass characteristics of steers fed conventional corn silage or SHREDLAGE at 9% or 14% dry matter.

	Chop Method		*P*	Silage Level			
	Conventional	SHREDLAGE®	value	14%	9%	*P* value	SEM
Initial BW, lb	926	930	NS	927	929	NS	2.7
DMI	22.42	22.10	0.02	22.32	22.21	NS	0.088
F:G	5.95	5.87	NS	5.94	5.88	NS	0.056
Final BW[2]	1408	1425	0.02	1409	1423	0.06	5.0
ADG	3.76	3.87	0.05	3.77	3.86	0.09	0.036
F:G	5.97	5.72	0.01	5.93	5.76	0.04	0.054
HCW, lb	887	898	0.02	888	897	0.06	3.1
LM, in	0.55	0.56	NS	0.54	0.56	NS	0.011
Marbling[3]	586	588	NS	578	597	0.07	6.8
Yield Grade[4]	3.19	3.11	NS	3.11	3.18	NS	0.053
Liver Score[5]	0.70	0.67	NS	0.67	0.70	NS	0.112
Normal, %	64	61		65	61		
A, %	13	15		15	13		
A+, %	23	24		20	26		

[1] $P > 0.2$ listed as NS

[2] Final BW = HCW/0.63

[3] 400 = Select^0; 500 = Small^0

[4] camera Yield Grade

[5] No abscess = 0; A = 1; A$^+$ = 2

Table 3. Simple effects for cattle performance.

	Chopped Silage		Shredded Silage		
Carcass BW basis	14%	9%	14%	9%	SEM
Final BW, lb	1399 [c]	1416 [b,c]	1419 [a,b]	1431 [a]	7.0
ADG	3.72 [c]	3.80 [a,b]	3.81 [a,b]	3.92 [a]	0.051
DMI	22.55 [b]	22.29 [a,b]	22.08 [a]	22.12 [a]	0.124
F/G	6.07 [c]	5.87 [b,c]	5.80 [a,b]	5.65 [a]	0.077
HCW	882 [c]	892 [b,c]	894 [a,b]	901 [a]	4.4

Liver status	Frequency, %			
Normal	69	60	61	62
A	14	12	16	14
A+	17	28	23	24

[a, b, c] means lacking a common superscript differ ($P<0.05$)

(Table 2). Liver scores were not significantly different across treatments.

Conclusion

These results suggest that a procedure that shreds silage, leaving larger particles, as opposed to conventional chopping results in improved performance over traditionally harvested corn silage. Including 9% silage improves feed efficiency and hot carcass weight compared to 14% silage.

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Evaluation of Two Implant Strategies, Revalor-XH or a Combination Revalor-IH/Revalor-200 on Heifer Growth Performance and Carcass Characteristics

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Summary and Implications

A commercial feedlot trial examined effects of two implant strategies (Revalor-IH on d 1 and re-implanted with Revalor-200 on d 101 or Revalor-XH on d 1) on growth performance and carcass characteristics of heifers fed 183 days. There were no differences between implant strategies for final body weight, dry matter intake, and average daily gain. Heifers implanted with the combination IH/200 treatment had improved carcass-adjusted feed conversion, greater LM area, and lower calculated yield grade compared to heifers implanted with XH. The response in growth performance between the two implant strategies suggests that the partially-coated Revalor-XH implant can be used in place of a more aggressive implant strategy when heifers are fed to similar days.

Introduction

Heifers given increased trenbolone acetate and estradiol tend to respond with increased growth performance and hot carcass weight. Heifers typically have reduced growth performance compared to steers due to increased fat deposition at the same age. To improve growth performance of heifers, feedlots may utilize aggressive implant protocols. Implanting once at the beginning of the feeding period with a long-lasting, delayed-release implant (Revalor-XH) may reduce potential stressors. The objective of this study was to evaluate implanting heifers with a partially coated Revalor-XH implant on d 1 compared to a more aggressive implant strategy of Revalor-IH on d 1 followed by Revalor-200 at a target of 80 d on terminal implant. Finishing heifer performance and carcass characteristics were measured.

Procedure

Crossbred heifers [n = 870; initial body weight (BW) = 710; SD = 19.6 lb] were utilized in a finishing study conducted at Hi-Gain Feedlot near Farnam, NE. The study had a generalized randomized block design with three blocks and two replications per block. Heifers were sourced from Nebraska (two replications), North Dakota and Montana (two replications), and Canada (2 replications). Heifers were fed for an average of 183 d (range 181–184 d) from May 2018 to November 2018. Treatments were: Revalor-IH on d 1 (80 mg trenbalone acetate (TBA)/8 mg estradiol (E2), noncoated, Merck Animal Health DeSoto, KS) and re-implanted with Revalor-200 on d 101 (200 mg TBA/20 mg E2, noncoated (IH/200), Merck Animal Health) or Revalor-XH on d 1 (200 mg TBA/20 mg E2, partially coated (XH); Merck Animal Health). Revalor-XH contains four uncoated pellets (80 mg TBA and 8 mg E2) for immediate release and six coated pellets (120 mg TBA and 12 mg E2) to release approximately 70 to 80 d after implanting.

Heifers were randomly assigned to pen (n = 12) by sorting every two heifers into one of two pens within replication prior to processing. Heifers were enrolled in the study over two days. Heifers were processed, pen weighed, and assigned to treatment in a single event. Animals were blocked based on origin source. Each block contained an equal number of pens per treatment. Pens were assigned randomly to treatment with 6 pens per treatment and an average of 73 animals per pen. Prior to enrollment, all heifers were checked for pregnancy. If pregnant, heifers were removed from the pool of qualified animals. At processing, heifers received their assigned implant, vaccine for protection against bovine rhinotracheitis virus and bovine viral diarrhea types one and two viruses (Bovi-shield Gold 5; Zoetis, Florham Park, NJ), external parasite control via dosing with 7 cc of moxidectin (Cydectin, Bayer Animal Health, Germany), and internal parasite control via drenching with 17 cc of fenbendazole (Safe-Guard, Merck) oral suspension. Implants were placed in the middle-third of the ear under the skin. Heifers assigned to IH/200 treatment were re-implanted 101 d after initial implanting. At reimplant, all implants were placed in the opposite ear of the initial implant.

Cattle were housed in open lots, with similar square feet allocated per animal across all pens, and ad libitum access to water and feed. Diets were constant across all treatments. All animals were adapted to a common finishing diet over a 27-d step up period consisting of four adaption diets. The finishing ration consisted of 65.3% steam-flaked corn, 18.0% wet distillers grains plus solubles, 4.5% mixed hay, 5.5% corn silage, 1.7% tallow, and 5.0% supplement (DM basis). Supplement was delivered daily via micro machine and formulated to provide 30 g/ton DM of Rumensin (Elanco Animal Health), 8.9 g/ton DM Tylan (Elanco Animal Health), 0.45 mg/hd/d of melengestrol acetate (MGA, Zoestis) and 250 mg/hd/d DM of Optaflexx (Elanco Animal Health). The nutrient composition of the finishing diet contained 14.6% crude protein, 6.6% crude fat, 1.04 Mcal/lb NEm, 0.72 Mcal/lb NEg, 0.7% Ca, 0.4% P, 0.7% K, and 0.2% S (DM basis). Optaflexx was targeted to be fed for 29 d at the end of the feeding period with a two d withdraw prior to slaughter. Diet samples were taken monthly and sent to a commercial laboratory (Servi-Tech Laboratories, Hastings, NE) for feed composition (DM, CP, NEm, NEg, Ca, P, K, and S). Weekly feed ingredient samples were taken to determine DM on site.

Cattle were scheduled for slaughter at approximately 183 d (range 181–184 d) on feed. Cattle were pen weighed prior to loading onto the truck to be shipped. Cattle were harvested at varying days on feed. Replications one and two were harvested at 181 days on feed and replications three,

Table 1. Performance and carcass characteristics of heifers implanted with Revalor-XH or Revalor-IH/200

	Treatment[1]			
Item	Rev-IH/200	Rev-XH	SEM	F-Test
Head Count	435	435	—	—
Days on Feed	183	183	—	—
Animals Removed, %	3.21	2.59	0.901	0.64
Death Loss, %	1.15	0.95	0.509	0.79
Live Performance				
Initial BW, lb	713	708	3.3	0.36
Final BW[2], lb	1393	1385	6.8	0.43
DMI, lb/d	23.9	24.2	0.18	0.33
ADG, lb	3.72	3.70	0.027	0.62
F:G	6.45	6.54	—	0.23
Carcass-Adjusted Performance				
Final BW[3], lb	1394	1380	7.3	0.21
ADG, lb	3.73	3.67	0.026	0.17
F:G	6.41	6.58	—	0.03
Carcass Characteristics				
HCW, lb	880	871	4.7	0.22
Dressing, %	63.14	62.87	0.17	0.28
LM area, in²	13.7	13.0	0.14	<0.01
Marbling[4]	512	497	5.6	0.11
12th rib fat, in	0.75	0.74	0.009	0.32
Calculated YG[5]	3.75	3.89	0.025	<0.01

[1]Treatments included: 1) Revalor-IH on d 1 (80 mg trenbalone acetate (TBA)/8 mg estradiol (E2), noncoated, Merck Animal Health DeSoto, KS) and re-implanted with Revalor-200 on d 101 (200 mg TBA/20 mg E2, noncoated (IH/200), Merck Animal Health); 2) Revalor-XH on d 1 (200 mg TBA/20 mg E2, partially coated (XH); Merck Animal Health). Revalor-XH contains four uncoated pellets (80 mg TBA and 8 mg E2) for immediate release and six coated pellets (120 mg TBA and 12 mg E2) to release approximately 70 to 80 d after implanting.

[2]Final BW is the average pen weight shrunk four percent. Subsequent ADG and F:G are calculated from shrunk final BW.

[3]Carcass-adjusted final BW was determined by dividing average HCW per treatment by the average dressing percent of 63.01%.

[4]USDA marbling scores. 400 = small, 500 = modest, 600 = moderate.

[5]YG = 2.50 + (2.5 * 12th-rib fat depth, in) + (0.2 * 3.0 KPH fat, %) + (0.0038 * HCW, lbs)—(0.32 * LM area, in²) where KPH fat was assumed to be 3.0 %.

four, five, and six were harvested at 184 days on feed. All heifers were harvested at a commercial abattoir (JBS Swift and Co., Grand Island, NE). Individual HCW was collected at slaughter. Following a 24-hr chill, 12th-rib fat depth, LM area, marbling, USDA quality grade, and USDA yield grade were collected from camera data. There were 11 carcasses removed from analysis due to missing carcass data or misidentified individual animal IDs. Therefore, carcass data were analyzed with 414 and 420 heifers in IH/200 and XH, respectively.

Performance and carcass data were analyzed as a generalized randomized block design using the MIXED procedure of SAS (9.4, SAS Institute Inc., Cary, NC). Treatment and block were fixed effects. The model included implant treatment and block. Pen was the experimental unit. Treatment averages were calculated using the LSMEANS option of SAS. Frequency data, such as USDA quality grade and yield grade distributions, were analyzed using the GLIMMIX procedure of SAS using a multinomial approach. Treatment differences were significant at $\alpha \leq 0.05$ and tendencies were discussed when $0.05 \leq \alpha \leq 0.10$.

Results

There were nine heifers that died over the course of the study. Sixteen heifers were removed from the trial due to respiratory disease, foot rot, or body injury. No differences ($P > 0.64$; Table 1) were observed between implant treatments for percent removed and mortality.

There were no differences ($P > 0.23$) in live final BW, dry matter intake (DMI), average daily gain (ADG), and feed conversion (F:G) due to implant treatment. There were no differences ($P > 0.17$) in carcass-adjusted final BW and ADG among implant treatments. Although not significant, carcass-adjusted ADG was 1.63% greater for heifers implanted with the combination IH/200 compared to heifers implanted with XH. Carcass-adjusted feed conversion improved 2.58% ($P = 0.03$) for heifers given IH/200 compared to heifers implanted with XH.

There were no differences ($P > 0.22$) in HCW, dressing percent, and 12th rib fat thickness among treatments. Heifers implanted with IH/200 had greater ($P = 0.01$) LM area compared to heifers implanted with XH. Calculated yield grade was greater ($P = 0.01$) for heifers given XH compared to heifers implanted with IH/200. The distribution of USDA yield grades tended to be significantly different ($P = 0.08$; Table 2) among treatments. The distribution of USDA quality grades was not different ($P = 0.35$) among treatments.

Conclusion

Overall, growth performance and carcass characteristics were relatively similar among IH/200 and XH treatments. However, heifers given IH/200 had improved carcass-adjusted feed efficiency, LM area, and calculated yield grade compared to heifers given XH. These data suggest when heifers are fed the same number of days the combination IH/200 implants can improve animal performance compared to the XH implant.

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Table 2. Quality grade and yield grade distribution of heifers fed for an average of 183 d implanted with Revalor-IH/200 or Revalor-XH

	Treatment[1]		
Item	Rev-IH/200	Rev-XH	*P*-Values
Quality Grade[2], %			
Prime	4.9	4.7	0.35
Upper Choice	45.2	43.3	
Choice	35.8	40.4	
Select	13.8	11.2	
Standard	0.2	0.3	
Yield Grade Distribution[2], %			
YG 1	0.9	0.9	0.08
YG 2	12.1	5.4	
YG 3	38.6	40.9	
YG 4	39.2	44.1	
YG 5	9.1	8.7	

[1]Treatments included: 1) Revalor-IH on d 1 (80 mg trenbalone acetate (TBA)/8 mg estradiol (E2), noncoated, Merck Animal Health DeSoto, KS) and re-implanted with Revalor-200 on d 101 (200 mg TBA/20 mg E2, noncoated (IH/200), Merck Animal Health); 2) Revalor-XH on d 1 (200 mg TBA/20 mg E2, partially coated (XH); Merck Animal Health). Revalor-XH contains four uncoated pellets (80 mg TBA and 8 mg E2) for immediate release and six coated pellets (120 mg TBA and 12 mg E2) to release approximately 70 to 80 d after implanting.

[2]All numbers are expressed as percentages. The yield grade and quality grade values represent the proportion of carcasses within each group that received a yield and quality grade.

Effect of Revalor-XH, Revalor-200, and Combination Revalor-IH/Revalor-200 on Yearling Heifer Growth Performance and Carcass Characteristics

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Summary and Implications

A commercial feedlot trial tested three implant strategies (Revalor-200 on day 0, Revalor-IH on d 0 and re-implanted with Revalor-200 on d 56, or Revalor-XH on d 0) on growth performance and carcass characteristics of heifers fed for 138 d. There were no differences observed for final body weight, dry matter intake, or average daily gain on a live basis among implant strategies. Heifers implanted with Revalor-IH/200 combination had greater carcass-adjusted final body weight and improved feed conversion compared to Revalor-200 and Revalor-XH. Hot carcass weights, dressing percent, and LM area were improved for Revalor-IH/200 implanted heifers relative to Revalor-200 and Revalor-XH implanted heifers. Marbling score and 12th-rib fat thickness were not different among implant treatments. Heifers implanted with Revalor-IH/200 had a shift to a lower USDA yield grade distribution compared to 200 and XH implanted heifers. The greater concentration of trenbolone acetate and estradiol provided by Revalor-IH/200 combination slightly improved growth and carcass performance compared to the non-coated Revalor-200 implant and partially coated Revalor-XH implant.

Introduction

Growth promoting implants improve average daily gain (ADG) and hot carcass weight (HCW) in steers and heifers. Cattle tend to respond to more aggressive terminal implant protocols with increased growth performance and delayed fattening at equal days on feed. Heifers tend to have more adipose tissue at the same chronological age as steers and therefore poorer growth performance. To improve growth rate, HCW, and feed efficiency, feeding programs typically have more aggressive implant protocols containing higher levels of trenbolone acetate (TBA) and estradiol (E2). The objective of this study was to evaluate effects of implanting heifers with a partially coated Revalor-XH implant on d 0 compared to non-coated Revalor-200 on d 0 or a more aggressive implant protocol of Revalor-IH on d 0 followed by Revalor-200 to target approximately 80 d with terminal implant on finishing heifer performance and carcass characteristics.

Procedure

Crossbred heifers (n = 1,728; initial BW = 906; SD = 24 lb) were utilized in a randomized complete block design with eight blocks. Heifers were sourced from sale barns in Nebraska and Oklahoma. Heifers were fed for an average of 138 d (range 135–139 d) from June 2018 to November 2018 in a commercial feedlot in Nebraska. Treatments included: Revalor-200 on d 0 (200 mg TBA/20 mg E2, Merck Animal Health, noncoated; 200), Revalor-IH on d 0 (80 mg TBA/8 mg E2, Merck Animal Health, noncoated) and re-implanted with Revalor-200 on approximately d 56 to target approximately 80 d with terminal implant (200 mg TBA/20 mg E2, Merck Animal Health, noncoated; IH/200), or Revalor-XH on d 0 [200 mg TBA and 20 mg E2, partially coated (XH); Merck Animal Health, DeSoto, KS]. Revalor-XH contains four uncoated pellets (80 mg TBA and 8 mg E2) for immediate release and six coated pellets (120 mg TBA and 12 mg E2) to release approximately 70 to 80 d after implanting.

Heifers were assigned randomly to pen (n = 24) based on weight strata at arrival. Pay weight and records of historical data of similar cattle at the feedlot were used to estimate range of two standard deviations above and below the pay weight. Heifers outside of this range were not used on the study. Within the range a series of randomization sheets were created, one for every 50 lb increment. Each row on every sheet contained a random assignment to treatment so that the first animal weighed that qualified for that stratum was assigned to one treatment while the next animal within that weight range was assigned to one of the remaining two treatments. Treatments were assigned randomly to pens within blocks for all 24 pens. Heifers were processed, weighed, and assigned to treatment in a single event on d 0. At processing, heifers received Vista Once SQ (Merck) to protect against bovine rhinotracheitis (IBR), parainfluenza$_3$ (PI$_3$), and bovine respiratory syncytial virus (BRSV); and an implant based on the assigned treatment. In addition, heifers received external parasite control via dosing with ivermectin (Noromectin, Norbrook) and internal parasite control via drenching with fenbendazole (Safe-Guard, Merck) oral suspension. All heifers were checked for pregnancy using rectal ultrasound, and if pregnant, were administered dinoprost tromethamine (Lutalyse HighCon, Zoetis) or both Lutalyse HighCon and dexamethasone if the heifer's fetus was determined to be 90 d or older to induce abortion. Implant sites were examined from four replications selected randomly from the eight total replications 28 d after initial implanting. All three pens from the chosen replications were checked with the first ten heifers out the gate selected. After re-implanting, the remaining four replications were checked but only the pens that had been re-implanted with Revalor-200. Pens from the remaining four replications that did not receive a terminal implant were not checked.

Cattle were housed in open lots with ad libitum access to water and feed. Diets were consistent across all treatments. Heifers were started on a diet consisting of 16.42%

Table 1. Performance and carcass characteristics of heifers implanted with three different strategies

	Treatment[1]				
Item	Rev-200	Rev-IH/200	Rev-XH	SEM	F-Test
Head Count[2]	508	505	506	—	—
Days on Feed	137.6	137.6	137.6	—	—
Animals Removed, %	0.38	0.40	0.42	0.251	0.99
Death Loss, %	1.22	0.17	0.21	0.312	0.06
Live Performance					
Initial BW	901	903	903	1.0	0.24
Final BW[3]*, lb*	1394	1398	1393	3.7	0.63
DMI, Ib/d	25.3	25.1	25.2	0.14	0.48
ADG, lb	3.58	3.60	3.56	0.029	0.67
F:G	7.09[b]	6.99[a]	7.09[b]	—	0.05
Carcass-Adjusted Performance					
Final BW[4]*, lb*	1389[b]	1405[a]	1390[b]	4.7	0.05
ADG, lb	3.55	3.65	3.54	0.037	0.09
F:G	7.14[b]	6.85[a]	7.09[b]	—	< 0.01
Carcass Characteristics					
HCW, lb	866[b]	876[a]	867[b]	3.0	0.05
Dressing, %	62.1[b]	62.7[a]	62.2[b]	0.0011	0.01
LM area, in[2]	13.6[b]	14.1[a]	13.7[b]	0.10	0.02
Marbling[5]	529	523	539	5.0	0.12
12th rib fat, in	0.71	0.68	0.70	0.010	0.17
Calculated YG[6]	3.82[a]	3.63[b]	3.75[ab]	0.048	0.05

[a, b] Means within rows without common superscripts differ ($P \leq 0.05$)

[1]Treatments included: Revalor-200 on d 0 (200 mg TBA/20 mg E2, Merck Animal Health, noncoated; 200), Revalor-IH on d 0 (80 mg TBA/8 mg E2, Merck Animal Health, noncoated) and re-implanted with Revalor-200 on approximately d 56 to target approximately 80 d with terminal implant (200 mg TBA/20 mg E2, Merck Animal Health, noncoated; IH/200), or Revalor-XH on d 0 [200 mg trenbalone acetate (TBA) and 20 mg estradiol (E2), partially coated (XH); Merck Animal Health, DeSoto, KS]. Revalor-XH contains four uncoated pellets (80 mg TBA and 8 mg E2) for immediate release and six coated pellets (120 mg TBA and 12 mg E2) to release approximately 70 to 80 d after implanting.

[2] Due to missing carcass data only replications 1–7 were analyzed for growth performance and carcass characteristics.

[3]Final BW is the average pen weight shrunk four percent. Subsequent ADG and F:G are calculated from shrunk final BW.

[4]Carcass-adjusted final BW was determined by dividing average HCW per treatment by the average dressing percent of 62.35%.

[5]USDA marbling scores. 400 = small, 500 = modest, 600 = moderate.

[6]YG = 2.50 + (2.5 * 12th-rib fat depth, in) + (0.2 * 3.0 KPH fat, %) + (0.0038 * HCW, lbs)—(0.32 * LM area, in^2) where KPH fat was assumed to be 3.0 %.

dry-rolled corn, 35.0% wet distillers grains plus solubles, 35.0% alfalfa hay, 10.0% corn stalks, 3.5% supplement, and 0.08% micro-ingredients (DM basis). Four step-up diets were used to transition the heifers to the finishing diet. Approximately 98 d (range 93–105 d) into the trial, dry-rolled corn was replaced with high-moisture corn for all animals on trial. The supplement and micro-ingredient premixes were formulated to target 8.9 g/ton DM of Tylan (Elanco Animal Health) and 30 g/ton DM of Rumensin (Elanco Animal Health). Melengestrol acetate (MGA, Zoetis) was fed at a rate of 0.45 mg/heifer daily once heifers reached the finishing ration. Actogain (Zoetis) was fed at a targeted rate of 300 mg/heifer for the last 35 d of the feeding period. Diet samples were obtained monthly and analyzed for dry matter, crude protein, crude fiber, calcium, phosphorous, potassium, sulfur, zinc, and copper.

Cattle were scheduled for slaughter at approximately 135 d (range 135–139 d) on feed. Cattle were shipped by pen with each pen on a separate truck and trucks were weighed and shrunk four percent to serve as the average final live weight. Cattle were processed at JBS in Grand Island, NE and individual carcass data were collected. Individual HCW was collected at slaughter. Following a 24 hr chill, 12th-rib fat depth, LM area, marbling, USDA quality grade, and USDA yield grade were collected from JBS's camera data. Carcass-adjusted final BW was calculated by dividing treatment average HCW by the average dressing percent of 62.35% across all study animals. In replication eight, carcass data were not collected on 31 carcasses from the 200 treatment. As a result, all live and carcass data from that replication were removed from analysis. Therefore, growth performance and carcass data were analyzed with 508 heifers in 200, 505 heifers in IH/200, and 506 heifers in XH (n = 1519; Table 1) as a RCBD with 7 blocks and 7 replications.

Percent mortality was calculated by the total number of animals that died in a pen divided by the total number of animals enrolled in that pen. Percent removed from study, excluding deads, was determined by dividing the number of cattle removed (i.e. lameness or injury) per pen by total number of heifers enrolled in that pen.

Performance and carcass data were analyzed as a randomized complete block design using the MIXED procedure of SAS (9.4, SAS Institute Inc., Cary, NC). Treatment and block were fixed effects. The model included implant treatments and blocks. Pen was the experimental unit. Treatment averages were calculated using the LSMEANS option of SAS. Frequency data, such as USDA quality grade and yield grade distributions, were analyzed using the GLIMMIX procedure of SAS using a multinomial approach. Treatment differences were significant at $\alpha \leq 0.05$ and tendencies were discussed when $0.05 \leq \alpha \leq 0.10$.

Results

There were eight heifers that died over the course of the study. Additionally, six heifers were removed from the trial due to bodily injury (i.e. dislocated hip, hoof issues, strained shoulder). No differences ($P \geq 0.99$) were observed between implant treatments for percent removed from the study. However, a tendency ($P = 0.06$) was observed for increased mortality with heifers implanted with 200 compared to IH/200 or XH implanted heifers.

Overall, no differences ($P = 0.48$; Table 1) were observed in live final BW, DMI, and live ADG among implant treatment. However, heifers implanted with IH/200 were

Table 2. Quality grade and yield grade distribution of heifers fed for an average of 138 d implanted with three different strategies

	Treatment[1]			
Item	Rev-200	Rev-IH/200	Rev-XH	*P*-Values
Quality Grade[2], %				
Prime	8.9%	8.0%	11.0%	0.55
Upper Choice	47.7%	46.1%	49.5%	
Choice	35.8%	34.6%	31.0%	
Select	7.3%	11.1%	8.5%	
Standard	0.2%	0.2%	0.0%	
Yield Grade Distribution[2], %				
YG 1	0.8%	1.5%	1.7%	<0.01
YG 2	13.3%	20.6%	12.7%	
YG 3	46.3%	44.7%	48.3%	
YG 4	33.3%	29.6%	34.0%	
YG 5	6.3%	3.6%	3.2%	

[1]Treatments included: Revalor-200 on d 0 (200 mg TBA/20 mg E2, Merck Animal Health, noncoated; 200), Revalor-IH on d 0 (80 mg TBA/8 mg E2, Merck Animal Health, noncoated) and re-implanted with Revalor-200 on approximately d 56 to target approximately 80 d with terminal implant (200 mg TBA/20 mg E2, Merck Animal Health, noncoated; IH/200), or Revalor-XH on d 0 [200 mg trenbalone acetate (TBA) and 20 mg estradiol (E2), partially coated (XH); Merck Animal Health, DeSoto, KS]. Revalor-XH contains four uncoated pellets (80 mg TBA and 8 mg E2) for immediate release and six coated pellets (120 mg TBA and 12 mg E2) to release approximately 70 to 80 d after implanting.

[2]All numbers are expressed as percentages. The yield grade and quality grade values represent the proportion of carcasses within each group that received a yield and quality grade.

1.42% more efficient, on a live basis, compared to heifers implanted with 200 or XH ($P = 0.05$). Carcass-adjusted final BW for heifers implanted with IH/200 were 16 and 15 lbs heavier than 200 and XH, respectively ($P = 0.05$). Carcass-adjusted ADG tended to be greater for heifers implanted with IH/200 compared to heifers implanted with 200 or XH ($P = 0.09$). Heifers implanted with IH/200 were 3.7% more efficient ($P < 0.01$), on a carcass-adjusted basis, compared to heifers implanted with 200 and XH.

Heifers implanted with IH/200 had 10 and 9 lbs greater HCW than 200 and XH, respectively ($P = 0.05$). Likewise, IH/200 implants improved dressing percentage and LM area compared to 200 and XH ($P \leq 0.02$). There were no differences ($P \geq 0.12$) in marbling score and 12th-rib fat thickness among implant strategies. Calculated USDA yield grade was improved for IH/200 treatment compared to 200 treatment, with XH treatment being intermediate ($P = 0.05$). The distribution of USDA quality grades was not different ($P = 0.55$; Table 2) among treatments. The distribution of USDA yield grades was significantly different ($P < 0.01$) with a shift from yield grade 3 and 4 to yield grade 2 for IH/200 heifers.

Conclusion

Heifers implanted with the combination IH/200 strategy had greater carcass adjusted ADG and HCW, and improved feed conversion (F:G). Final BW, DMI, and ADG were not different among implant treatments when based on live performance. The greater concentration of TBA and E2 provided by IH/200 combination improved carcass weight and performance compared to the non-coated 200 implant and partially coated XH implant. While no differences in growth performance and carcass characteristics were observed among 200 and XH implant treatments.

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Impact of Feeding Syngenta Enhanced Feed Corn as Dry-Rolled Corn, High-Moisture Corn, or a Blend to Finishing Yearlings

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Summary with Implications

A finishing study evaluated the effect of corn hybrid and processing type on finishing performance of yearling steers. Treatment design was a 2×3+1 factorial, with two hybrids that included a conventional commercial corn (CON) and Syngenta's Enogen Feed Corn (EFC). Corn was processed and fed as dry-rolled corn (DRC), high-moisture corn (HMC), or a 50:50 blend of the two for each hybrid. An additional treatment included 50% EFC DRC and 50% CON HMC, to evaluate a blend of the two hybrids and processing types. An interaction between hybrid and processing method was observed for ADG and F:G. Cattle fed EFC had numerically improved F:G and similar ADG when fed EFC compared to CON as DRC or a 50:50 ratio of DRC:HMC. For cattle fed HMC, ADG and F:G were better for CON compared to EFC, leading to the interaction. Cattle fed a blend of EFC as DRC with CON as HMC performed similar to those fed a blend of the CON hybrid. Feeding Enogen Feed Corn may improve performance when processed as DRC but results were not statistically different than feeding the CON hybrid despite a 3% improvement in efficiency.

Introduction

Replacing roughage with corn grain in feedlot cattle diets increases the energy density of the diet substantially, which can increase gain and efficiency. Starch is the major energy component in corn, and must be digested by cattle either in the rumen by microbes or the intestine by enzymatic digestion from the cattle. Syngenta Enogen Feed Corn (EFC; Syngenta Seeds, LLC) has been genetically enhanced to contain an α-amylase enzyme trait. This trait may result in improved animal performance by increasing post-ruminal starch digestion. Previous research has observed an improvement in F:G and an increase in post-ruminal starch digestion when EFC was fed as dry-rolled corn (DRC), compared to cattle fed corn not containing the α-amylase enzyme trait (*2018 Nebraska Beef Cattle Report*, pp. 92–94; *2016 Nebraska Beef Cattle Report*, pp. 135–138; *2016 Nebraska Beef Cattle Report*, pp. 143–145). However, the same response has not been observed when cattle were fed high-moisture corn (HMC; *2016 Nebraska Beef Cattle Report*, pp. 143–145).

A majority of producers who utilize HMC feed it as a ratio with DRC; therefore, the objective of this study was to evaluate EFC when fed at different ratios as either 100% DRC, 100% HMC, or a 50:50 blend of DRC:HMC.

Table 1. Dietary treatment compositions (DM basis) for finishing steers fed Enogen or control hybrids as dry-rolled corn, high-moisture corn, or a blend.

Trait	CON[1]			EFC[2]			EFC/CON[3]
Processing Method	DRC	Blend	HMC	DRC	Blend	HMC	Blend
Dry-Rolled Corn CON[1]	70.0	35.0	-	-	-	-	-
Dry-Rolled Corn Enogen[2]	-	-	-	70.0	35.0	-	35.0
High-Moisture Corn CON[1]	-	35.0	70.0	-	-	-	35.0
High-Moisture Corn EFC[2]	-	-	-	-	35.0	70.0	-
Wheat Straw	5.0	5.0	5.0	5.0	5.0	5.0	5.0
MDGS	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Supplement[4]	5.0	5.0	5.0	5.0	5.0	5.0	5.0

[1]CON= Commercially available corn grain without the alpha amylase enzyme trait

[2]EFC = Syngenta Enogen Feed Corn provided by Syngenta under identity-preserved procedures, stored, and processed as dry-rolled corn (DRC) or high-moisture corn (HMC), and fed separately

[3]EFC/CON= 50/50 Blend of EFC DRC and CON HMC.

[4]Supplement contained 0.5% urea, limestone, trace minerals, vitamins ADE, and was formulated to provide 30g/ton Rumensin® (Elanco Animal Health, DM Basis) and 8.8g/ton Tylan® (Elanco Animal Health, DM Basis)

Procedure

A 148-d finishing study, utilizing 336 crossbred yearling steers (BW = 915 ± 37 lb) in a randomized block design, was conducted at the Eastern Nebraska Research and Extension Center (ENREC) feedlot near Mead, Nebraska. Steers were limit fed a diet consisting of 50% alfalfa hay and 50% Sweet Bran (Cargill; Blair, NE) at 2.0% BW for five consecutive days to equalize gut fill. Steers were then weighed on two consecutive days and the average was used as initial BW. Cattle were implanted with Revalor 200® (Merck Animal Health) on d 1 of the trial. Steers were blocked by BW into light and heavy BW blocks (n = 3 replicates for each BW block) based on d 0 BW, stratified by BW and assigned randomly to 1 of 42 pens, with pens assigned randomly to 1 of 7 treatments. There were 8 steers/pen and 6 replications/treatment.

Dietary treatments (Table 1) included 1) conventional commercial corn processed as HMC (CON HMC), 2) CON

Table 2. Effect of corn hybrid and processing method on cattle performance and carcass characteristics

	Treatments								P-Values					
	CON[1]			EFC[2]			EFC/CON[3]		Main Effects		Int.[4]		Hybrid Effect[5]	
	DRC	Blend	HMC	DRC	Blend	HMC	Blend							
Pens	6	6	6	6	6	6	6	SEM	Hybrid[6]	L Proc.[7]	L	Q	DRC	HMC
Performance														
Initial BW, lb	919	919	919	920	919	919	919	0.6	0.28	0.30	0.66	0.44	0.21	0.53
Final BW, lb[8]	1459	1460	1479	1455	1470	1448	1464	9.4	0.27	0.49	0.18	0.11	0.72	0.03
DMI, lb/d	26.4	24.9	24.2	25.4	24.9	23.8	24.8	0.29	0.03	<0.01	0.33	0.16	0.01	0.24
ADG, lb[8]	3.65	3.66	3.78	3.61	3.73	3.58	3.68	0.064	0.25	0.45	0.21	0.10	0.66	0.03
Feed:Gain[8]	7.25	6.82	6.41	7.04	6.68	6.66	6.74	-	0.85	<0.01	0.09	0.47	0.30	0.16
Carcass Characteristics														
HCW, lb	919	920	932	916	926	912	922	5.9	0.25	0.49	0.18	0.11	0.71	0.03
Ribeye Area, in	13.6	13.9	14.4	13.8	13.9	14.1	14.1	0.21	1.00	0.02	0.23	0.84	0.44	0.35
Marbling Score[9]	525	493	526	497	511	526	489	15.0	0.78	0.32	0.38	0.22	0.20	0.97
Back Fat Thickness, in	0.66	0.60	0.65	0.63	0.67	0.64	0.62	0.026	0.63	0.92	0.55	0.07	0.38	0.96

[1]CON= Commercially available corn grain without the alpha amylase enzyme

[2]EFC = Syngenta Enogen Feed Corn provided by Syngenta under identity-preserved procedures, stored, processed as corn silage.

[3]EFC/CON= 50/50 Blend of EFC DRC and CON HMC.

[4]Interaction effects of hybrid type and grain processing

[5]Effect of hybrid type on grain processing

[6]Main effect of hybrid type.

[7]Linear effect of grain processing

[8]Calculated from hot carcass weight, adjusted to a common 63% dressing percentage

[9]Marbling Score 400-Small00, 500 = Modest00

processed as DRC (CON DRC), 3) a 50/50 blend of CON HMC and CON DRC (CON BLEND), 4) Syngenta Enogen Feed Corn processed as HMC (EFC HMC), 5) EFC processed as DRC (EFC DRC), 6) a 50/50 blend of EFC HMC and EFC DRC (EFC BLEND), and 7) a 50/50 blend of EFC DRC and CON HMC (EFC/CON BLEND). Steers were adapted over a 5 diet, 21-d step-up period, where by-product and wheat straw inclusions were held constant, while corn replaced alfalfa hay.

Steers were harvested on day 149 at Greater Omaha (Omaha, NE). During harvest, hot carcass weight (HCW) was recorded and carcass-adjusted final BW was calculated from a common 63% dressing percentage. Carcass characteristics included marbling score, 12th rib fat thickness, and LM area, which were recorded after a 48-hr chill.

Data were analyzed using the PROC GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.) as a randomized block design, with pen as the experimental unit and block as a fixed effect. The treatment design was a 2×3+1 factorial. Linear and quadratic interaction effects of hybrid and grain processing were evaluated for the 2×3 factorial. If no significant interactions were detected, then main effects of hybrid and corn processing were evaluated. If a significant interaction existed, then simple effects of hybrid within processing method were compared. Preplanned contrasts compared CON versus EFC within each processing method, and CON BLEND to EFC/CON BLEND.

Results

There were no interactions between corn hybrid and processing method for initial BW, DMI, ribeye area, or marbling score ($P \geq 0.16$, Table 2). A tendency for a quadratic interaction was observed for HCW and final BW between hybrid and processing method. Cattle fed the CON hybrid as DRC weighed the least and weights increased as HMC inclusion increased. Cattle fed EFC had lower weights when it was fed as DRC or HMC, thus, the response to processing was different. A quadratic interaction was observed for ADG between processing and hybrid (Figure 1). The ADG was numerically greater for cattle fed EFC as DRC or the blend of DRC:HMC, but then ADG did not further increase for cattle fed EFC as HMC like was observed for the CON hybrid. Furthermore, a linear interaction was observed ($P = 0.09$) for feed efficiency between hybrid and processing method. Feed conversion improved as HMC inclusion increased. However, this improvement was greater in cattle fed the CON hybrid compared to the EFC hybrid (Figure 2).

In general, when fed as DRC or fed as a blend of DRC:HMC, steers fed EFC

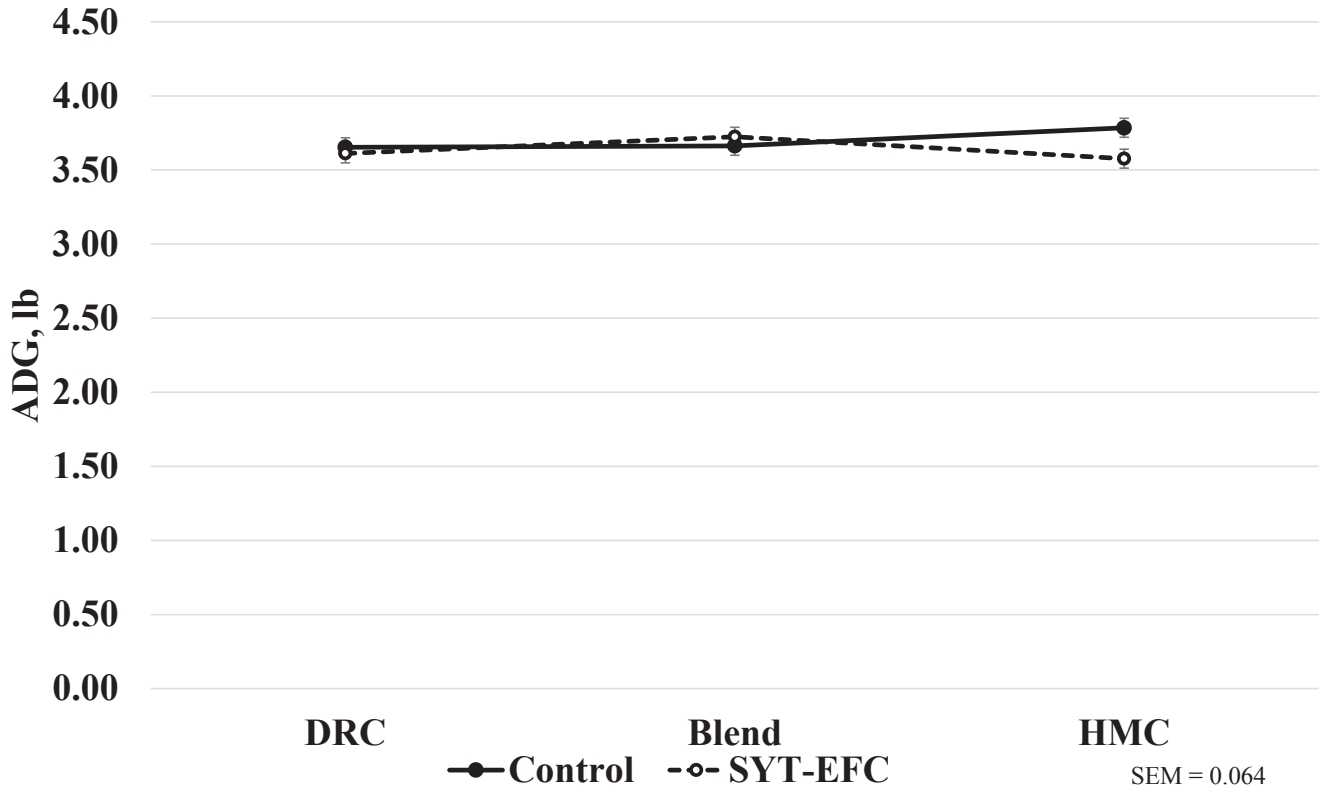

Figure 1. Effect of corn hybrid and processing method on average daily gain.

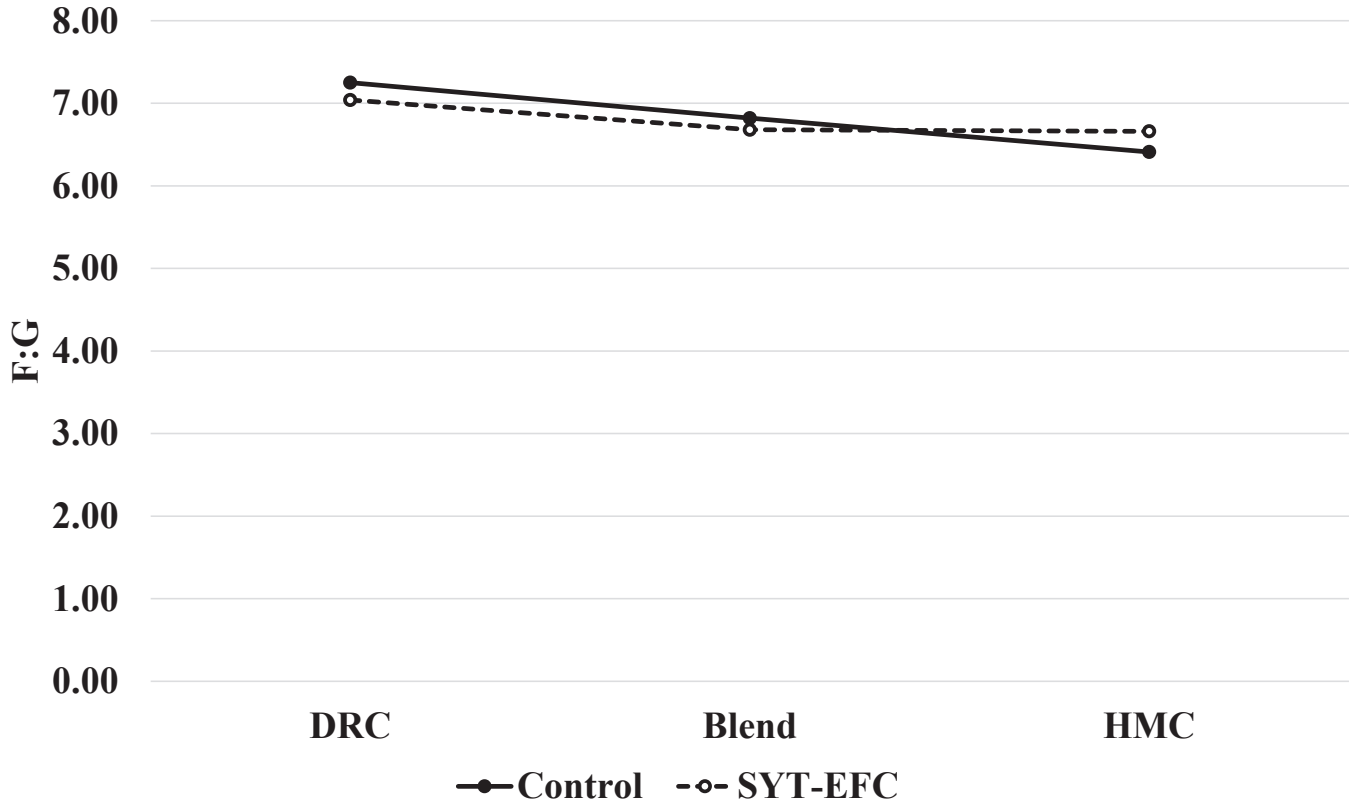

Figure 2. Effect of corn hybrid and processing method on feed to gain ratio.

had similar ADG, but lower or equal DMI, resulting in numerically lower F:G compared to the CON DRC or BLEND. The improvement of F:G was about 3% for EFC compared to CON when fed as DRC which equates to a 4.3% improvement in the grain itself (70% inclusion). This was not statistically different based on the pairwise comparison ($P = 0.30$). When fed as HMC, steers fed CON had greater ADG ($P = 0.03$), and numerically better F:G ($P = 0.16$) compared to EFC. Previous data suggested that when fed as HMC, no differences were observed between EFC and comparable control hybrids (*2016 Nebraska Beef Cattle Report*, pp. 143–145).

As expected, as DRC was replaced with HMC, DMI decreased while ADG was fairly similar which showed that feeding HMC improved F:G compared to DRC and the blend of 50:50 DRC:HMC was generally intermediate to feeding either alone.

A blend of EFC DRC and CON HMC was compared to the blend of control DRC and HMC (CON BLEND). No significant effects were observed for any of the growth performance or carcass characteristic parameters measured ($P \geq 0.47$).

Conclusion

Finishing cattle with Syngenta Enogen Feed Corn as DRC, HMC, or a 50/50 blend of the two did not statistically improve any of the growth performance or carcass characteristics that were measured. However, cattle fed the EFC BLEND had numerically heavier final BW, greater ADG, improved F:G, greater HCW, increased marbling score, and greater back fat thickness compared to those fed the CON BLEND. Additionally, steers consuming EFC DRC had numerically lower F:G than those fed CON DRC.

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Dose Titration of Wet Distillers Grains plus Solubles Replacing Syngenta Enogen Feed Corn and Interaction between Corn Type and Distillers Inclusion

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Summary with Implications

An incomplete 2×4 factorial finishing study evaluated the effect of corn hybrid fed as dry-rolled corn, and inclusion level of wet distillers grains plus solubles on finishing performance of yearling steers. The two hybrids included a conventional commercial corn and Syngenta's Enogen Feed Corn which contains an alpha amylase enzyme trait. Diets contained 0, 15, 30, or 45% with Syngenta Enogen Feed Corn and 0 or 30% wet distillers grains plus solubles in control corn diets. Increasing wet distillers grains plus solubles with Syngenta Enogen Feed Corn linearly increased hot carcass weight, dry matter intake, and average daily gain, while improving feed conversion. When comparing cattle fed Syngenta Enogen Feed Corn to control with 0 or 30% wet distillers grains plus solubles, no significant differences were observed for any of the performance characteristics. Nonetheless, steers fed Syngenta Enogen Feed Corn with 0% wet distillers grains plus solubles had 3% numerically better feed conversion, but was similar to control when 30% wet distillers grains plus solubles were fed.

Introduction

Traditionally, feed efficiency and starch digestion in beef cattle have been increased via corn processing methods (rolling, ensiling, steam flaking, etc.). However, increased corn processing also results in an increased risk of acidosis, as more rapidly fermentable grains enter the rumen. To maximize animal performance, starch digestion must be enhanced while limiting the risk of digestive upsets. Syngenta Enogen Feed Corn (EFC; Syngenta Seeds, LLC) has been genetically enhanced to contain an α-amylase enzyme trait. This trait may result in improved animal performance by increasing post-ruminal starch digestion. Previous research has observed a decrease in F:G and an increase in post-ruminal starch digestion when EFC was fed as DRC, compared to cattle fed corn not containing the α-amylase enzyme trait (*2018 Nebraska Beef Cattle Report*, pp. 92–94; *2016 Nebraska Beef Cattle Report*, pp. 135–138; *2016 Nebraska Beef Cattle Report*, pp. 143–145). However, this response has been variable across studies.

One question that remains unanswered is how EFC interacts with varying distillers grains inclusions. Increased protein entering the small intestine could enhance post-ruminal starch digestion. The objective of this study was to evaluate EFC when fed with different inclusions of wet distillers grains plus solubles on finishing beef cattle performance.

Table 1. Dietary treatment compositions (DM Basis) for finishing steers fed Syngenta Enhanced Feed Corn or Control hybrids as dry-rolled corn, with titrating levels of WDGS.

Trait	EFC[1]				CON[2]	
WDGS Inclusion:	0[4]	15	30	45	0[4]	30
Control DRC[2]	0	0	0	0	79	49
EFC DRC[1]	79	64	49	34	0	0
WDGS	0	15	30	45	0	30
Corn Silage	15	15	15	15	15	15
Liquid Supplement[3]	6	6	6	6	6	6

[1]EFC = Syngenta Enhanced Feed Corn provided by Syngenta under identity-preserved procedures, stored, and processed as dry-rolled corn (DRC).

[2]Control = Commercially available corn grain without the alpha amylase enzyme trait.

[3]Supplement for all diets formulated to provide 30g/ton Rumensin® (Elanco Animal Health, DM Basis), 8.8g/ton Tylan® (Elanco Animal Health, DM Basis).

[4]Supplement for the 0% WDGS diets formulated to provide 4.31% CP (1.5% urea), 0.64% Ca, and ≥ 10,820 IU Vitamin A.

Supplement for the 15% WDGS diet formulated to provide 1.44% CP (0.5% urea), 0.64% Ca, and ≥ 10,820 IU Vitamin A.

Supplement for the 30 and 45% WDGS diets formulated to provide 0.64% Ca, and ≥ 10,820 IU Vitamin A.

Procedure

A 154-d finishing study, utilizing 480 crossbred yearling steers (BW = 829 ± 69 lb) in a randomized block design, was conducted at the Panhandle Research and Extension Center (PHREC) feedlot near Scottsbluff, Nebraska. Steers were limit fed a diet consisting of 50% alfalfa hay and 50% Sweet Bran (Cargill; Blair, NE) at 2.0% BW for five consecutive days to equalize gut fill. Steers were then weighed on two consecutive days and the average was used as initial BW. Steers were blocked by BW into light, medium and heavy BW blocks (n = 2, 4 and 2 replicates respectively) based on d 1 BW, stratified by BW and assigned randomly to 1 of 48 pens, with pens assigned randomly to 1 of 6 treatments. There were 10 steers/pen and 8 replications/treatment. Cattle were implanted with Revalor 200® (Merck Animal Health) on d 35 of the trial.

Dietary treatments (Table 1) were arranged in an incomplete 2 × 4 factorial, and included 1) Syngenta Enogen Feed Corn processed as DRC with 0% WDGS (EFC 0), 2) EFC with 15% WDGS (EFC 15), 3) EFC with 30% WDGS (EFC 30), 4) EFC with 45% WDGS (EFC 45), 5) conventional commercial corn processed as DRC with 0% WDGS (CON 0), and 6) CON with 30% WDGS (CON 30). Steers were adapted over a 21-d step-up period, with WDGS and corn silage inclusions held constant, while DRC replaced alfalfa hay.

Steers were harvested on day 155 at a

Table 2. Effect of corn hybrid and distillers inclusion on cattle performance and carcass characteristics

	Treatments[1]							*P*-Values			
Hybrid	EFC[2]				Control[3]		SEM	Main Effects of DGS		EFC vs. CON[4]	
Distillers Incl.	0	15	30	45	0	30		Linear[5]	Quadratic[6]	0 vs. 0	30 vs. 30
Pens	8	8	8	8	8	8					
Performance											
Initial BW, lb	829	829	829	830	829	829	0.5	0.83	0.24	0.41	0.62
Final BW, lb	1416	1450	1469	1471	1406	1457	10.6	<0.01	0.12	0.49	0.41
DMI, lb/d	25.35	26.11	26.38	26.54	25.68	25.93	0.292	<0.01	0.29	0.40	0.26
ADG, lb[7]	3.81	4.03	4.16	4.16	3.75	4.08	0.068	<0.01	0.11	0.51	0.42
Feed:Gain	6.66	6.48	6.41	6.38	6.87	6.37	-	0.04	0.45	0.17	0.69
Carcass Characteristics											
HCW, lb	892	913	926	926	886	918	6.7	<0.01	0.12	0.51	0.42
LM Area, in	14.7	14.7	14.5	14.3	14.7	14.7	0.175	0.09	0.58	1.00	0.35
Back Fat Thickness, in	0.55	0.63	0.70	0.67	0.52	0.64	0.018	<0.01	<0.01	0.37	0.01
Marbling Score[8]	553	553	541	561	546	556	12.9	0.82	0.42	0.70	0.39

[1]DRC based diets with titrating levels of WDGS inclusions from 0 to 45%, all diets included supplement at 6%.

[2]EFC = Syngenta Enhanced Feed Corn provided by Syngenta under identity-preserved procedures, stored, and processed as dry-rolled corn (DRC).

[3]Control = Commercially available corn grain without the alpha amylase enzyme trait.

[4] Contrast comparison of EFC and Control DRC with 0 and 30% distillers inclusion.

[5] Linear effect of distillers grains inclusion levels on EFC.

[6] Quadratic effect of distillers grains inclusion levels on EFC.

[7]Calculated from hot carcass weight.

[8] Marbling score 400 = Small00, 500 = Modest00

commercial abattoir (Cargill, Fort Morgan, CO). During harvest, hot carcass weight (HCW) was recorded and carcass-adjusted final BW was calculated from a common 63% dressing percentage. Carcass characteristics included marbling score, 12th rib fat thickness, and *Longissimus* muscle (LM) area, which were recorded after a 48-hr chill.

Data were analyzed using the PROC GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.) as a randomized block design, with pen as the experimental unit and block as a fixed effect. Data were analyzed as a 2×2 factorial, evaluating corn type and WDGS inclusion interaction for CON and EFC with 0 or 30% WDGS. Additionally, linear and quadratic orthogonal contrasts evaluated the impact of replacing EFC DRC with 0, 15, 30, and 45% inclusion of WDGS.

Results

Orthogonal contrasts were used to evaluate the effect of WDGS inclusion when replacing 0, 15, 30, or 45% DRC (Table 2). No effects were observed for initial BW or marbling score ($P \geq 0.24$). A linear effect ($P < 0.01$) was observed for HCW and carcass-adjust final BW, with cattle consuming increased levels of WDGS having greater carcass weights. There was a linear increase in DMI as WDGS inclusion increased from 0 to 45%. Furthermore, ADG linearly increased, with steers gaining more as WDGS inclusions increased in the diet from 0 to 45% ($P < 0.01$). Due to increased DMI and ADG, cattle consuming increased inclusions of WDGS had a linearly decrease in F:G ($P = 0.04$). A tendency for a linear decrease in LM area was observed ($P = 0.09$). A quadratic effect was observed for back fat thickness. Cattle consuming increased levels of WDGS had greater back fat, with steers on 0% WDGS having the least amount and those on 30% WDGS having the greatest fat thickness ($P < 0.01$).

Contrasts were used to evaluate the effect of hybrid type and WDGS inclusion for the 0% and 30% inclusion diets. No significant differences were observed for any of the performance parameters or carcass characteristics evaluated when comparing cattle fed EFC with those fed CON with 0% WDGS ($P \geq 0.17$). However, cattle fed EFC with 0% WDGS had numerically greater ADG and lower F:G compared to those on the CON 0% diet ($P = 0.17$). The improvement in F:G was 3% for the diet suggesting the corn was 4% better for feed efficiency (3/0.79). This numerical response has been consistent across numerous experiments.

Furthermore, no significant differences were observed for any of the performance parameters evaluated when comparing steers consuming the EFC hybrid with those fed the CON hybrid with 30% WDGS ($P \geq 0.26$). Fat thickness was greater for cattle consuming EFC compared to those on the CON diet, when WDGS was included at 30% (0.70 and 0.64 respectively; $P = 0.01$).

Conclusion

Feeding finishing beef cattle increasing inclusions of WDGS linearly increased HCW, DMI, ADG, and feed efficiency in diets containing EFC hybrid corn. Furthermore, an increase in WDGS inclusion resulted in a quadratic increase in back fat thickness in steers fed EFC based diets. When comparing the effect of hybrid, no statistical differences were observed among cattle consuming diets with 0% WDGS, despite the observation of a 3% numerical improvement in feed conversion. No performance changes were observed between EFC and CON when diets contained 30% WDGS.

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Effect of Urea and Distillers Inclusion in Dry-Rolled Corn Based Diets on Heifer Performance and Carcass Characteristics

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Summary with Implications

Crossbred heifers (n=96, BW = 810 ± 20) were utilized to evaluate the effects of increasing wet distillers grains plus solubles and urea inclusion in a dry rolled corn based finishing diet on performance and carcass characteristics. Heifers were individually fed using a calan gate system with a 2 × 2 factorial arrangement of treatments. Factors included distillers inclusion at either 10 or 20% of diet DM and urea inclusion at either 0.2 or 1.4% of diet DM. There was no difference for final body weight, average daily gain, and feed conversion on a live or carcass adjusted basis for either urea or distillers inclusion in the diet. Dry matter intake was reduced with increased urea inclusion; however, distillers inclusion did not influence intake. Added distillers and urea in the diet had minimal impact on performance suggesting supplemental urea in a dry rolled corn based finishing diets is of minimal benefit when feeding at least 10% distillers grains.

Introduction

Distillers grains are a good source of protein usually containing approximately 30% crude protein (CP) with 63% of the CP being in the form of rumen undegradable protein (RUP). When metabolizable protein is fed at concentrations above the animal's requirements, the protein is deaminated and the carbon skeleton is used as energy. The nitrogen from the protein is then packaged as urea and enters into circulation where it can be filtered by the kidney and excreted in the urine or recycled back to the rumen. It has long been known that nitrogen (N) is recycled in the ruminant animal. Although some estimates have been established it is still largely unknown how much N recycling takes place when supplying MP in excess of the animal's requirement. Some studies would suggest, that when including wet distillers grains plus solubles (WDGS) at levels between 10 and 20% of the diet, supplemental urea is of minimal benefit to animal performance (*2019 Nebraska Beef Cattle Report*, pp 97–102).

Table 1. Treatment Diet Composition and MP balance

	10% Distillers		20% Distillers	
Ingredient Inclusion, % DM	0.2% Urea	1.4% Urea	0.2% Urea	1.4% Urea
DRC, %	71.5	70.3	61.5	60.3
WDGS, %	10	10	20	20
Corn Silage, %	15	15	15	15
Urea, %	0	1.2	0	1.2
Supplement[1], %	3.5	3.5	3.5	3.5
CP, %	11.2	14.6	13.5	16.8
MP Balance[2], g/d	137	125	253	240
RDP Balance[2], g/d	-204	140	-126	218
RDP Corrected MP[3], g/d	6	125	172	240

[1] Purina Steakmaker contained 5.6% urea which contributed to a total dietary urea inclusion of 0.2% of diet DM

[2] Based on the 2000 revised NRC model using cattle initial BW and trial average ADG and DMI.

[3] MP balance calculated taking into account RDP deficiency (MP—|(RDP * 0.64)|)

While some previous research has addressed supplementing RDP in diets containing low levels of WDGS (*2018 Nebraska Beef Cattle Report*, pp. 93–95) it remains largely unknown what the optimal level of urea supplementation is in DRC based diets containing 20% or less WDGS. With more feedlots beginning to feed distillers at lower inclusions between 10 and 20% the objective of this study was to determine the amount of urea that needs to be supplemented to meet rumen degradable protein (RDP) requirements of finishing cattle.

Procedure

Ninety six crossbred heifers were fed at the United States Meat Animal Research Center (USMARC) near Clay Center, Nebraska. Cattle were housed in a facility with Calan-headgates which allowed for the measurement of individual feed intake. Cattle were all fed a common diet prior to initiation of the trial and BW was measured on two consecutive days using a single-animal scale. Cattle were implanted with a Revalor IH on d 0 followed by a Revalor 200 on d 70.

The experiment was set up as a completely randomized design with a 2 × 2 factorial arrangement of treatments. Factors consisted of WDGS inclusion (10 or 20% of diet DM), and urea inclusion (0.2 or 1.4% of diet DM). There were two basal diets utilized in this trial (Table 1). The supplement fed to all diets contained 5.6% urea which contributed to a total dietary urea inclusion of 0.2% of diet DM. Thus the 1.4% urea treatment had 1.2% additional urea added to the diet.

Performance data (ADG, DMI, F:G, and initial and final BW), carcass characteristics (HCW, LM area, 12th rib fat, marbling score, and USDA yield grade) were analyzed using the MIXED procedure of SAS with treatment as a fixed effect. Individual animal served as the experimental unit.

Results

A tendency was observed ($P = 0.08$) for an interaction between urea and WDGS inclusion for marbling score. Cattle fed 10%

Table 2. Main Effects of WDGS inclusion on animal performance and carcass characteristics.

Measure	10% WDGS	20% WDGS	SEM	*P*-Value
Live Performance				
Initial, lb	809	811	9.3	0.89
Final BW, lb	1197	1194	14.3	0.88
ADG, lb/d	2.79	2.75	0.05	0.62
DMI, lb	19.8	19.4	0.26	0.29
F:G	7.04	6.94	-	0.75
Carcass Adjusted				
Final BW, lb	1195	1191	12.7	0.81
ADG, lb/d	2.78	2.73	0.05	0.47
F:G	7.09	7.04	-	0.83
Dressing, %	63.1	62.9	0.21	0.63
Carcass Characteristics				
HCW, lb	753	750	8.6	0.81
LM Area, in^2	12.6	12.6	0.38	0.79
12^{th} rib fat, in	0.81	0.80	0.03	0.76
Marbling[1]	493	492	11.2	0.97
CYG[2]	3.86	3.80	0.093	0.67

[1] $400 = small^{00}$, $450 = Small^{50}$, $500 = Modest^{00}$.

[2] Calculated as 2.5 + (6.35 × 12^{th} rib fat, in) + (0.2 × 3.0[KPH]) + (.0017 × HCW, lb)—(2.06 × LM Area, in^2) USDA, 1997.

Table 3. Main effects of urea inclusion on animal performance and carcass characteristics

Measure	0.2% Urea	1..4% Urea	SEM	*P*-Value
Live Performance				
Initial, lb	810	810	9.3	0.97
Final BW, lb	1202	1190	14.3	0.55
ADG, lb/d	2.82	2.73	0.05	0.26
DMI, lb	20.0	19.2	0.26	0.03
F:G	7.04	6.94	-	0.71
Carcass Adjusted				
Final BW, lb	1199	1186	8.6	0.51
ADG, lb/d	2.80	2.70	0.05	0.19
F:G	7.09	7.04	-	0.73
Dressing, %	62.9	63.1	0.21	0.65
Carcass Characteristics				
HCW, lb	756	747	8.6	0.51
LM Area, in^2	12.5	12.7	0.15	0.48
12^{th} rib fat, in	0.83	0.78	0.03	0.11
Marbling[1]	499	485	11.2	0.38
CYG[2]	3.94	3.72	0.093	0.10

[1] $400 = small^{00}$, $450 = Small^{50}$, $500 = Modest^{00}$.

[2] Calculated as 2.5 + (6.35× 12^{th} rib fat, in) + (0.2 × 3.0[KPH]) + (.0017 × HCW, lb)—(2.06 × LM Area, in^2) USDA, 1997

WDGS had increased marbling score when urea was included in the diet; however, cattle fed 20% WDGS had decreased marbling score when urea was included in the diet. While a tendency for this interaction was observed it has little biological relevance to this study and is attributed, instead, to random variation in the data. There were no other significant interactions ($P > 0.61$) observed between WDGS and urea inclusion for performance or carcass characteristics. Therefore, only main effects will be presented for performance and carcass characteristics.

Main effects for WDGS inclusion are presented in Table 2. There were no differences ($P \geq 0.29$) observed for WDGS inclusion for initial BW, final live BW, live ADG, DMI, or live G:F. Additionally, no differences were observed ($P \geq 0.47$) for carcass adjusted final BW, ADG, G:F, or dressing %. Carcass characteristics (HCW, LM area, 12^{th} rib fat thickness, marbling score, and USDA calculated yield grade) were not different ($P \geq 0.67$) between the two WDGS inclusions.

Main effects of urea inclusion are presented in Table 3. There were no observed difference ($P \geq 0.26$) between urea inclusions for initial BW, final live BW, live ADG, or live F:G. A difference ($P = 0.03$) was observed for DMI with cattle fed the diet with 1.2% urea having lower DMI than e cattle consuming no added urea. However, even with a lower DMI F:G was not different ($P = 0.73$) between treatments, due to a numerical reduction in ADG. Additionally, there were no observed differences ($P \geq 0.10$) for any carcass parameters measured (HCW, LM area, 12^{th} rib fat thickness, marbling score, and USDA calculated yield grade) in this study between the two urea levels.

Conclusion

In the present study the addition of urea to diets containing either 10 or 20% WDGS had no effect on animal performance or carcass characteristics. These data would suggest that when feeding DRC based diets that added urea is not necessary when at least 10% WDGS is included in the diet. However, with the low urea diets containing 0.2% of diet DM urea a conservative approach would be to include 0.2% urea in diets containing 10% WDGS.

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Impact of Myoglobin Oxygenation State on Color Stability of Frozen Beef Steaks

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Summary with Implications

The objective of this study was to determine the impacts of myoglobin oxygenation level and frozen storage duration on frozen beef color. Strip loins were wet-aged for 4 or 20 days and were fabricated into steaks that were assigned a myoglobin oxygenation level (highly oxygenated, lowly oxygenated, or deoxymyoglobin) and packaging film (impermeable or permeable). Steaks were then frozen for 0, 2, 4, or 6 months of storage and analyzed for various beef color measurements. Highly oxygenated steaks had greater a values (redness) and percent oxymyoglobin compared to the other treatments. Frozen storage beyond 4 months and oxygen impermeable packaging tended to have detrimental effects on beef color. Highly oxygenated steaks that are aged for 4 d displayed superior red color for extended storage with few undesirable effects.*

Introduction

Meat color is the number one factor influencing consumer purchase decisions. Typically, fresh beef can be associated with three different myoglobin states: deoxymyoglobin (purplish color associated with intact beef), oxymyoglobin (bright red cherry color associated with beef that has been exposed to oxygen), and metmyoglobin (brownish color prominent once beef has become oxidized). The emerging market of frozen meat highlights the need to understand beef surface discoloration and the optimal color parameters of freezing beef to retain a superior, bright red cherry color. Improving understanding of beef surface discoloration and the ideal parameters to freeze beef color, could lead to an increase in revenue for the beef industry. Therefore, the objectives of this study were to determine the impacts of oxygenation level and frozen storage duration on frozen beef color.

Procedure

Thirty-six USDA Choice strip loins were aged for 4 d or 20 d. For each loin, 0.5 inch steaks were fabricated and randomly assigned to a myoglobin oxygenation level [deoxymyoglobin (DeOxy; fabricated and immediately packaged), low oxygenation (LoOxy; oxygenated in air for 30 m, allowing it to bloom), and high oxygenation (HiOxy; packaged for 24 h in a modified atmosphere packaging mixture of 80% O_2 and 20% CO_2)]. Steaks were then vacuum packaged in oxygen permeable film or impermeable film and immediately frozen (-4°F). Following either 0, 2, 4, or 6 months of frozen storage, steaks were removed from the packaging and immediately analyzed (while frozen) for oxygen penetration, instrumental color (L*, a*, b*), delta E, percent oxymyoglobin, metmyoglobin, and deoxymyoglobin (via spectrometer), redness ratio (calculated as 630nm/530nm via spectrometer), subjective discoloration, and lipid oxidation. A one inch cut from the lateral end of the steak was made to measure oxygen penetration using a Westward caliper measuring the penetration depth of the bright red cherry oxymyoglobin color from the surface of the steak. Instrumental color was measured via colorimeter measuring L* (darkness to lightness), a* (greenness to redness), and b* (blueness to yellowness); delta E was measured as the magnitude of difference in the L*, a*, b* color space from the initial fabrication day till the designated frozen storage period. Delta E was calculated using the formula $\Delta E=((\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2)^{1/2}$. Percent oxymyoglobin, metmyoglobin, and deoxymyoglobin were determined using a portable spectrometer (Quality Spec® Trek Malvern Panalytical) using the isobestic wavelengths and redness ratio was calculated as 630nm/530nm using the portable spectrometer. Subjective percent discoloration was evaluated by a panel of five trained panelists using a percentage surface scale where 0% meant no discoloration and 100% meant complete surface discoloration. Lipid oxidation or thiobarbituric acid reactive substance values (TBARS) were established via the amount of mg of malonaldehyde per kg of muscle tissue.

All data were analyzed as a split-split plot design with age as the whole-plot, frozen storage as the split-plot and a three by two factorial of oxygenation level and packaging film as the split-split plot. Frozen storage period was analyzed as an incomplete block design with each loin containing two random storage periods. Loin was considered the experimental unit. The data were analyzed using the PROC GLIMMIX procedure of SAS with the LS MEANS statement. Statistical significance was determined at $P < 0.05$.

Results

The HiOxy steaks had greater oxygen penetration (bright red cherry color depth) and greater a* values (Figure 1), when compared to DeOxy and LoOxy regardless of packaging film ($P<.0005$). Conversely, DeOxy steaks exhibited the lowest a* values (lowest redness) regardless of packaging film ($P<.0005$). This was expected since the HiOxy steaks were exposed to greater concentrations of oxygen allowing oxygen to bind to the heme ring and produce a bright red color typical of oxymyoglobin. The HiOxy steaks that were aged for 4 d had greater a* values than DeOxy and LoOxy at all frozen storage times ($P=.0118$). In addition, HiOxy 20 d steaks had the highest delta E values (10.79), compared to all other treatments at six months of frozen storage ($P=.0057$). Increasing frozen storage time

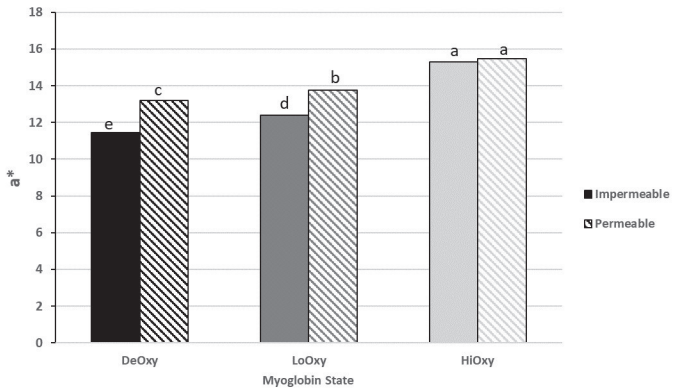

Figure 1. Instrumental color values for a* (redness) of steaks in either a deoxymyoglobin (DeOxy), low oxygenated (LoOxy), or high oxygenated (HiOxy) state and impermeable or permeable packaging.
[a, b, c, d, e] Different superscripts indicated differences among treatments (P<0.05).

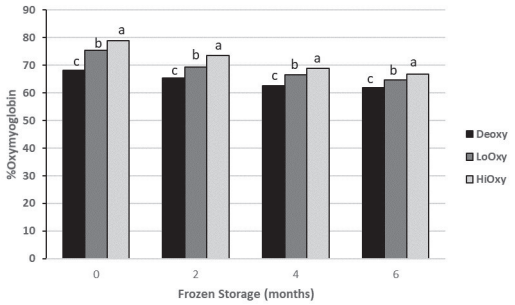

Figure 2. Instrumental color values for percent oxymyoglobin of steaks in either a deoxymyoglobin (DeOxy), low oxygenated (LoOxy), or high oxygenated (HiOxy) state compared within frozen storage period.
[a, b, c] Different superscripts indicated differences within frozen storage period (*P*<0.05).

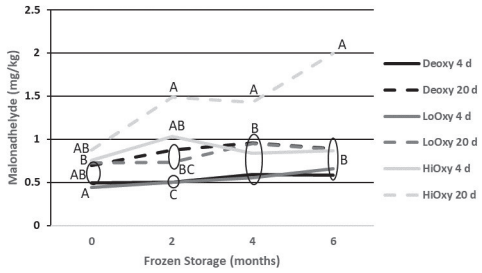

Figure 3. Lipid oxidation (TBARS) values of steaks in either a deoxymyoglobin (DeOxy), low oxygenated (LoOxy), or high oxygenated (HiOxy) state and either aged for 4 or 20 d compared within frozen storage period.
[a, b, c] Different superscripts indicated differences within frozen storage period (*P*<0.05).

led to an increase in delta E values for the HiOxy steaks ranging from 3.88 to 10.79 representing a noticeable difference in visual color (*P*=.0057). Delta E is used to measure the change in total color over time. Therefore, a larger delta E value would represent a larger change in color during frozen storage.

Percent oxymyoglobin (Figure 2) and redness ratio values were highest for HiOxy steaks within each frozen storage period (*P*<.0002). The HiOxy and LoOxy steaks had similar percent oxymyoglobin when in permeable packaging film that allowed the oxygen to pass through the film. The DeOxy steaks had the lowest percent oxymyoglobin and HiOxy steaks had the highest percent oxymyoglobin within each aging and frozen storage period (*P*<.01). Conversely, HiOxy steaks had the lowest percent metmyoglobin and DeOxy steaks had the highest percent metmyoglobin when packaged in impermeable film that inhibited oxygen passage through the film (*P*<.0001). Lowest percent metmyoglobin values were from the 4 d HiOxy steaks at 2, 4, and 6 months of frozen storage (*P*=.0188).

The HiOxy 20 d steaks had the greatest percent discoloration compared to 4 d aging and more discoloration than all other myoglobin treatments at 6 months of storage (*P*<.0001). Lipid oxidation, indicating the amount of rancidity, increased with frozen storage time (*P*=.0169). The HiOxy steaks aged for 20 d exhibited the greatest TBARS values (Figure 3) at 2, 4, and 6 months of frozen storage (*P*=.0224). The HiOxy 4d steaks and LoOxy steaks were similar in discoloration and lipid oxidation.

The HiOxy steaks exhibit a brighter and deeper cherry red color compared to the DeOxy steaks. The HiOxy steaks were superior or similar in various beef color measurements when compared to LoOxy steaks. However, as frozen storage was extended, HiOxy steaks started to display more detrimental effects compared to the LoOxy steaks. Based on the results, HiOxy steaks that are aged for 4 d give a superior red color for extended storage with few undesirable effects. However, it is not advised to freeze deoxygenated steaks and expect a bright red cherry color through frozen storage.

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Effects of Relative Humidity on Meat Quality in Dry Aged Beef

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Summary with Implications

During dry-aging, water is transferred from the interior to the meat surface and is subsequently evaporated to the surrounding environment. There is a common belief in the meat industry that rapid drying creates a hard crust on the meat surface, which would act as a protective barrier against moisture loss, holding moisture on the inside of the product. This phenomenon is called case hardening. If this hypothesis is correct, drying at low relative humidity would be recommended in order to get case hardening and avoid excessive yield loss. This study was conducted to evaluate the effects of relative humidity on moisture loss and flavor in dry-aged beef. No case hardening effects occurred, even at 50% relative humidity. Results suggest lower relative humidity results in more rapid moisture loss at the beginning of the aging process without significantly affecting the total amount of moisture loss. Lower relative humidity tended to associate with more desirable flavor notes.

Introduction

Although enhanced flavor has been extensively used to promote dry-aged beef, evidence that dry aging benefits flavor is still unclear. During dry aging, water is evaporated and flavor compounds are concentrated, making the beef flavor stronger. However, not all studies have found improved flavor for dry-aged beef. These conflicting results may be associated with inconsistent environmental conditions applied during the dry aging process.

Relative humidity (RH) is important because it can affect the water evaporation rate. If RH is too low, excess product shrinkage and crust formation occur due to rapid evaporation of water. Conversely, if RH is too high, spoilage bacteria can grow and result in off-flavors. The objective of this research was to evaluate the impact of low RH during dry aging on moisture and trim loss, tenderness, and flavor. The working hypothesis was rapid drying would create a hard crust on the meat surface that could reduce moisture release over time, thereby reducing weight loss, enhancing tenderness (by retaining more water), and altering flavor when compared with dry aging at higher RH.

Procedure

Sixteen USDA low Choice boneless strip loins were assigned to 1 of 4 aging treatments: vacuum (Wet), dry-aging at 50% RH (RH50), dry-aging at 70% RH (RH70), or dry-aging at 85% RH (RH85). Loins were placed in individual dry aging chambers and aged for 42 days at 35°F and 2200 revolutions per minute (RPM) fan speed. Wet-aged loins were stored in vacuum packages in the same cooler for 42 days. After aging, loins were trimmed of dehydrated lean/fat, fabricated into steaks and evaluated for trim loss, yield, tenderness via Warner-Bratzler shear force (WBSF), and sensory analysis.

A computerized dry aging system was designed and built capable of measuring and precisely controlling RH (± 1 %), temperature (± 0.9 °F), and air velocity (± 50 RPM). The chambers have built-in weighing scales that can continuously monitor weight loss (± 5 g). All measured data can be saved on the connected computer in intervals of 1 second. The percentage daily water loss for dry-aged loins was calculated as the difference between the prior day weight and current weight divided by the prior day weight. The percentage total water loss for dry-aged loins was calculated as the difference between initial weight and final weight divided by the initial weight. The dry-aged loins were then further processed by trimming dried surfaces and non-edible fat, and reweighed to calculate the yield (%) after aging and trimming. The processing weight loss for the wet-aged loins during aging was calculated as the difference between initial weight and purge loss.

Steak internal temperature and weight were recorded prior to cooking. Fresh (never frozen) steaks (1 inch thick) were cooked to a target temperature of 160°F on a Belt Grill. After cooking, internal temperature and weight were recorded. Then, steaks (n = 16) were individually bagged and stored overnight at 36°F for further WBSF analysis. The following day, six (½ inch diameter) cores were removed with a drill press parallel to the orientation of the muscle fibers. Cores were sheared using a Food Texture Analyzer with a Warner-Bratzler blade. Peak WBSF values from each steak were averaged for statistical purposes.

Triangle tests were conducted in two sessions with 32 consumers each. In the first session, panelists were served samples from the RH50% and RH85% treatments to compare the extremes in dry aging conditions. In the second session, panelists were served samples from the Wet and RH70% treatments to compare wet aging to dry aging. Each panelist received three, 3-digit blind coded samples (½ inch × ½ inch × 1 in thickness) cut by avoiding the edges and fat kernels of the steaks. Two of these samples were identical and one was different. Panelists were asked to circle the number of the sample they perceived to be different in flavor.

A beef flavor attribute panel was trained to scale ten basic flavors from the beef lexicon on a 16-point intensity scale (0 = none and 15 = extremely intense). For sample testing, panelists (n = 6) were served two random cubes (½ inch × ½ inch × 1 in thickness) assigned a 3-digit blind code, avoiding the edges and fat kernels of the

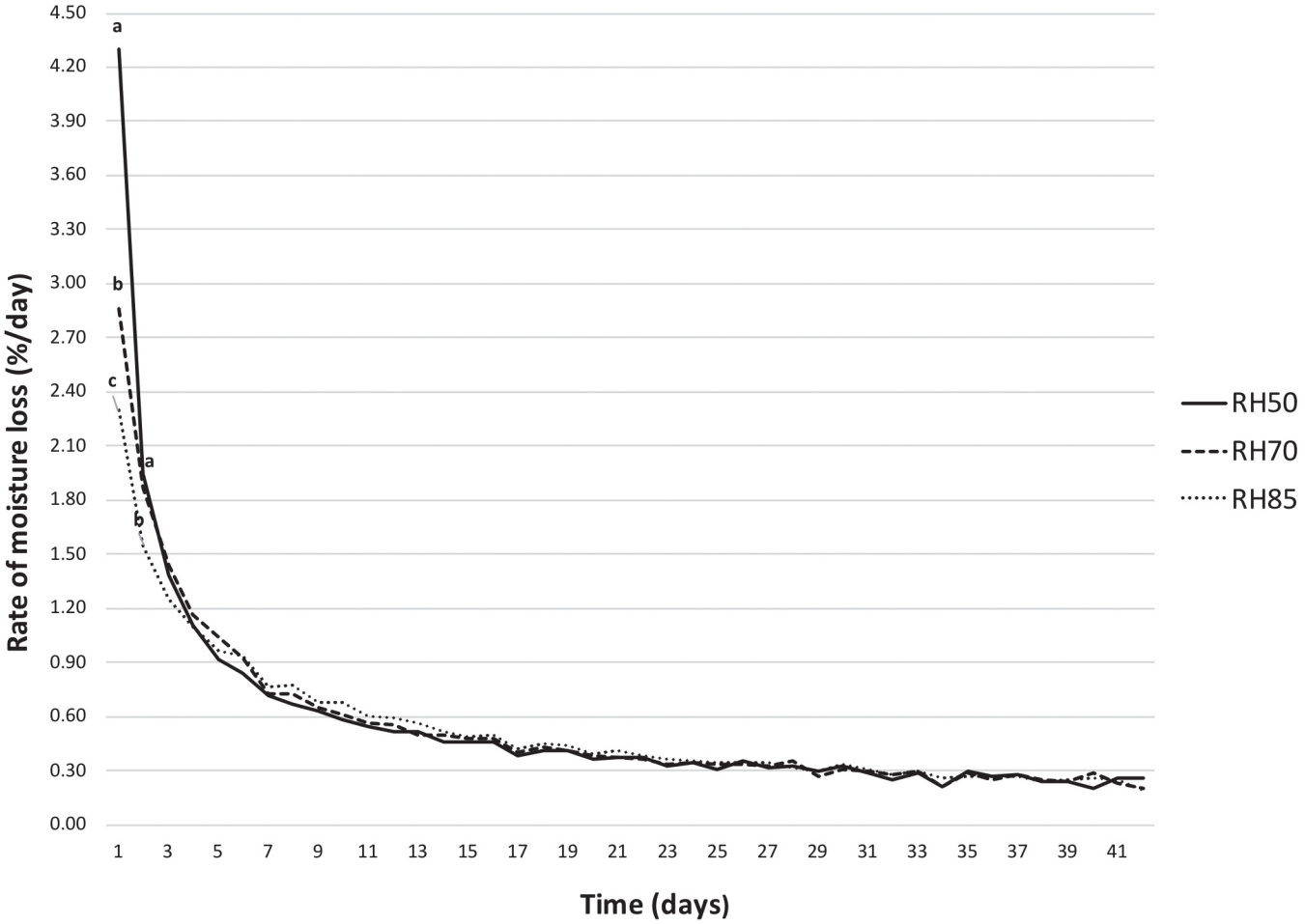

Figure 1. Rate of moisture loss (%/day) of strip loins dry aged for 42 days at 50, 70 or 85% relative humidity (RH).

Table 1. Total moisture loss, trim loss, yield, and Warner-Bratzler shear force values of strip loins wet or dry aged for 42 days at 50, 70 or 85% relative humidity.

	Treatment				
	Wet	RH50%	RH70%	RH85%	*P*-value
Moisture loss (%)	1.14[a]	23.87[b]	23.20[b]	22.64[b]	< 0.05
Trim loss (%)	0.0[a]	14.86[b]	14.58[b]	14.99[b]	< 0.05
Yield (%)	98.86[a]	61.27[b]	62.22[b]	62.37[b]	< 0.05
WBSF (kg)	2.62	2.56	2.29	2.27	0.66

[a,b] Means in the same row with different superscripts differ ($P < 0.05$).

steak, in a plastic cup while in a breadbox style booth under red lighting. Salt-free crackers and double-distilled, deionized water were offered as palette cleansers.

Rate of moisture loss was analyzed as a complete randomized design with day of aging as the repeated measure. Trained panel results were analyzed using principal component analysis (PCA). All the other data were analyzed as a completely randomized design. Chamber (loin) was considered the experimental unit (n = 16; 4/treatment). Data were analyzed using the PROC GLIMMIX procedure of SAS with α = 0.05.

Results

Wet-aged samples had lower moisture loss, trim loss and higher yield than all dry-aged treatments ($P < 0.05$, Table 1). The rate of moisture loss for dry-aged treatments is presented in Figure 1. The RH50 treatment had a faster rate of moisture loss than RH85 on the first day of aging ($P < 0.05$), while RH70 was intermediate. The RH50 and RH70 treatments had faster rates of moisture loss than RH85 on days 2 and 3 of aging ($P < 0.05$). From day 4 onward, no differences in rate of moisture loss among RH treatments were found ($P > 0.05$). There were no differences among RH treatments for total moisture loss, trim loss, and yield ($P > 0.05$). There is a commonly-held belief in the meat industry that rapid drying creates a protective crust on the meat surface, thereby locking in moisture. However, this research showed the protective crust concept is incorrect. The lower RH resulted in more rapid moisture loss (days 1 to 3) without significantly affecting the total amount of moisture loss after 42 days. This suggests RH has relatively little effect on weight loss.

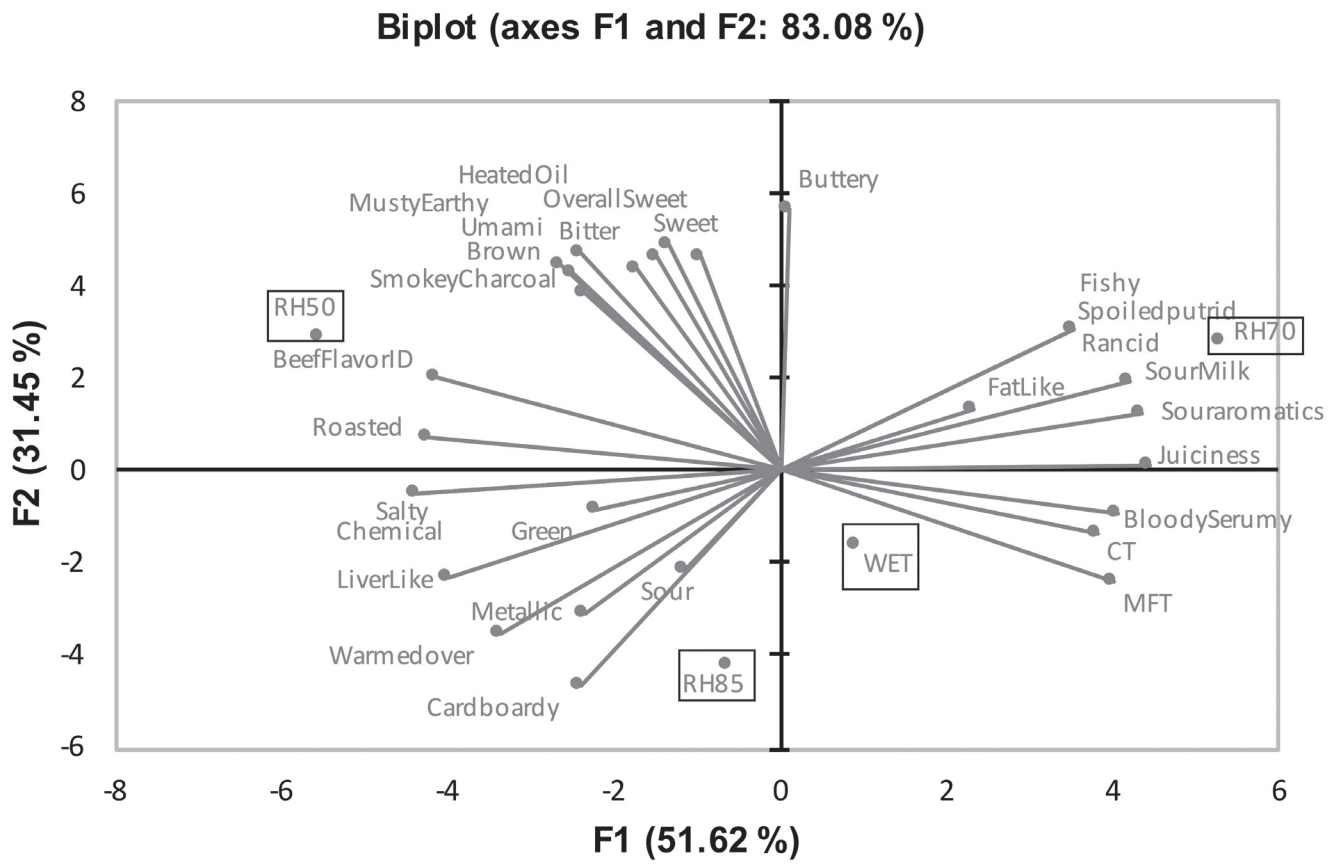

Figure 2. Principal component biplot of sensory attributes where RH50 = dry aged loins at 50% relative humidity (RH), RH70 = dry aged loins at 70% RH, RH85 = dry aged loins at 85% RH, and WET = wet aged loins for trained sensory panel.

No differences among treatments for WBSF were found ($P = 0.66$; Table 1). Improvements in tenderness through the aging process occur regardless of the aging method used (wet or dry) as the mechanism of beef tenderization (proteolysis) is independent of oxygen. Although dry aging improves beef tenderness, this aging method has not been used to promote a tenderness advantage in comparison to wet aging; instead, dry aging is mainly used for intensifying flavors.

Results from the triangle test indicated consumers detected a difference in flavor between Wet and RH70 ($P = 0.02$). However, consumers did not detect flavor differences between RH50 and RH85 ($P = 0.14$). No differences among treatments were found for flavor notes using analysis of variance. Using PCA, two factors explained 83% of the variation in sensory attributes (Figure 2). The RH50 treatment tended to be associated with relatively positive flavor notes, including beef flavor identity, roasted, umami, smoky/charcoal, heated oil, bitter, and brown flavor. The RH70 treatment tended to associate with sour milk, sour aromatics, rancid, and fishy flavor, while RH85 tended to associate with oxidized flavors like cardboard, warmed-over, metallic, green, liver-like and sour flavor notes. Wet aged steaks were fairly neutral in flavor notes. The lower RH results in more rapid moisture loss at the beginning of the aging process without significantly affecting the total amount of moisture loss. Trim loss, yield, and tenderness were not affect by RH during dry aging. These results suggest speed of moisture loss does not impact the quality of dry-aged beef.

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Impact of Feeding NaturSafe® (An Immune Support Product) on Beef Quality

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Summary with Implications

The objective of this study was to evaluate the effects of feeding NaturSafe® and the potential impact on meat quality characteristics in beef. Steers were fed one of five diets: a control with dietary antibiotics, a control without dietary antibiotics, or a diet without antibiotics containing 12 g/d/, 15 g/d/, or 18 g/d/ of NaturSafe® for a period of 112 d. Following harvest, strip loins were collected, aged for 13 or 29 d and placed under retail display conditions for 0 or 7 d. Feeding NaturSafe® at 12 g/d or 15 g/d resulted in tenderness (shear force) values less than or equal to the control diets. Differences in color were observed between the NaturSafe® levels and the control diets. However, feeding NaturSafe® had minimal discernible effects overall, on meat quality.

Introduction

NaturSafe® (Diamond V, USA) is a *Saccharomyces cerevisiae* fermentation product developed as a natural nutritional health product used in beef rations to enhance rumen and immune health. NaturSafe® has been specifically formulated to optimize beef cattle health, and performance, antibiotic stewardship, and food safety. Previous research has shown that NaturSafe® supports optimal rumen and liver health, overall animal health and immune function, consistency of feed intake, daily gain, feed conversion, and antibiotic effectiveness. However, little research has been conducted to evaluate the potential impact of NaturSafe® on beef quality. Therefore, the objective of this research was to characterize the effects of feeding NaturSafe® on beef quality characteristics.

Procedure

Sixty crossbreed steers (mean hot carcass weight = 928 lb.) were individually fed for 112 d through an antibiotic free production system. Cattle were randomly assigned to one of the five diet treatments (12 head per treatment): 12 g/d, 15 g/d, or 18 g/d of NaturSafe®, control diet without (-AB) antibiotics, or a control with antibiotics (+AB; 330 mg monensin + 110 mg tylosin·steer-1·d^{-1}). Following harvest, strip loins from the right side of the carcass were collected and wet-aged for 13 d or 29 d postmortem. Fat and lean cores were excised for microbiological evaluation prior to fabrication of steaks. From each strip loin three one-inch steaks were fabricated: one steak for tenderness measurements at 0 d of retail display, one steak for instrumental color, subjective color, and tenderness measurements after 7 d of retail display, and one steak for all other laboratory analysis. Laboratory analysis included: pH, sarcoplasmic calcium concentration, troponin-T degradation, fatty acid profile, proximate composition, sarcomere length, total collagen and insoluble collagen. One half inch steak was also fabricated and cut in half [half for lipid oxidation 0 d and half for lipid oxidation after 7 d of retail display]. After fabrication all steaks used for retail display were placed on foam trays, overwrapped with oxygen permeable film, and placed under simulated retail display conditions for 7 d at 37°F. The same fabrication scheme was used for both aging periods of 13 and 29 d. Microbiological analyses were conducted for aerobic plate counts (APC), psychotropic plate counts (PPC), and lactic acid bacteria (LAB) plate counts. Tenderness was measured using the Warner-Bratzler shear force (WBSF) method, sarcomere length was measured via laser diffraction, free Ca^{2+} concentration was analyzed via inductively coupled plasma spectroscopy following high-speed centrifugation, pH was measured via pH meter, and troponin-T degradation was analyzed via immunoblotting. Fatty acid profile was measured via gas chromatography, and collagen was measured via amount of total and insoluble collagen present in lean. Proximate composition including: moisture and ash (%) were measured via Thermogravimetric Analyzer, fat content was measured via ether extraction, and protein content measured via calculated differences. Lipid oxidation or Thiobarbituric acid reactive substance values (TBARS) were measured via the amount of mg of malonaldehyde per kg of muscle tissue subjected to retail display periods of 0 d or 7 d. Instrumental color was measured via colorimeter measuring L* (lightness), a* (redness), and b* (yellowness) and a portable spectrometer was used to measure percentage surface of oxymyoglobin, metmyoglobin, and deoxymyoglobin. Subjective discoloration was also evaluated daily during retail display by a panel of five trained panelists using a percentage scale where 0% meant no discoloration and 100% meant complete surface discoloration.

Sarcomere length, pH, fatty acid profile, proximate composition, total collagen, insoluble collagen, were analyzed as a completely randomized design. Free Ca^{2+} concentration, troponin-T degradation, and percentage of oxymyoglobin, metmyoglobin, and deoxymyoglobin were analyzed as a split-plot design with dietary treatment as the whole plot and aging period as the split-plot. The APC, PPC, LAB, WBSF, and TBARS data were analyzed as a split-split plot design with dietary treatment as the whole-plot, aging period as the split-plot and days of retail display as the split-split plot. The L*, a*, b* values and subjective discoloration data were analyzed as a split-split-plot design with day of retail display considered as a repeated measure. Animal was considered the experimental unit and

Table 1. Analytical measures of strip loins steaks from steers fed a control diet without antibiotics, control diet with antibiotics, or 12 g/d, 15 g/d, or 18 g/d NaturSafe®.

	Dietary Treatment					
	Control No DV, No antibiotics	Control-Antibiotics	12 g/d NaturSafe®	15 g/d NaturSafe®	18 g/d NaturSafe®	P-Value
WBSF (lbs of force)	6.99[a]	5.73[b]	5.56[b]	5.51[b]	7.01[a]	.0013
Sarcomere Length (µm)	1.68	1.64	1.69	1.66	1.65	.5408
pH	5.58	5.56	5.57	5.59	5.58	.9063
Calcium (µm)	92.74	83.76	83.96	90.75	96.71	.1779
Troponin-T Degradation (%)	14.26	16.62	18.20	20.14	17.57	.3330
Total Collagen (mg/g)	5.28	4.65	4.52	4.69	4.22	.5006
Insoluble Collagen (mg/g)	4.03	4.35	3.70	3.99	3.73	.8348
Soluble Collagen (mg/g)	1.48	1.69	1.71	.31	.47	.7075
Moisture (%)	70.59	70.43	70.91	70.97	71.02	.8263
Protein (%)	19.11	18.39	19.01	19.13	19.14	.2349
Fat (%)	8.57	9.36	8.23	7.98	8.03	.3801
Ash (%)	1.74	1.83	1.85	1.92	1.81	.4311
Discoloration 13 d[1]	.08[b]	0.00[b]	.25[b]	0.00[b]	.27[b]	.0010
Discoloration 29 d[1]	1.40[b]	1.08[b]	2.00[b]	8.03[a]	.76[b]	.0010
Lipid Oxidation (mg malon-aldehyde/kg)	1.98	1.79	1.81	1.67	1.62	.5438
Metmyoglobin (%)	23.02	22.55	23.76	24.49	24.66	.7326
Deoxymyoglobin (%)	1.84[c]	3.05[bc]	3.25[bc]	5.80[a]	4.60[ab]	.0077
Oxymyoglobin (%)	75.14	74.40	72.99	69.71	70.75	.1562
Aerobic Plate Count (log cfu/cm^2)	5.63	5.41	5.58	5.71	5.63	.7309
Psychotropic Plate Count (log cfu/cm^2)	3.94	3.33	3.70	4.17	4.17	.9558
Lactic Acid Bacteria (log cfu/cm^2)	8.51	8.38	8.33	8.13	8.21	.5004
SFA (%)[†]	44.59	44.87	44.18	44.43	44.32	.9344
UFA (%)[†]	55.29	55.08	55.74	55.43	55.63	.9146
MUFA (%)[†]	51.55	51.42	52.12	51.82	51.69	.9347
PUFA (%)[†]	3.74	3.60	3.62	3.62	3.94	.8216
Trans Fatty Acid (%)	2.24	2.28	2.19	1.99	2.17	.5433

[a-c] Means in the same column with different superscripts are different (P<0.05).

[1 a-d] Indicate differences among aging periods and treatments (P<0.05).

[†]SFA = saturated fatty acids, UFA= unsaturated fatty acids, MUFA = monounsaturated fatty acids, and PUFA = polyunsaturated fatty acids.

hot carcass weight and marbling score were used as covariates in the analysis. Data was analyzed using the PROC GLIMMIX procedure of SAS with the LS MEANS statement and TUKEY adjustment. Statistical significance was determined at $P < 0.05$.

Results

There were no dietary treatment effects for APC, PPC, and LAB (P=.7309, P=.9558, and P=.5004, respectively). However, aging time affected PPC, with 29 d having a higher amount of colony forming units (CFU) than 13 d (P<.0001). Allowing the beef to age would allow psychotropic bacteria to grow and multiply, contributing to the increase in CFU. Microbiological analyses were conducted to determine if feeding NaturSafe® reduced the prevalence of microbial growth on the lean. A reduction of microbes could lead to beef with longer shelf life and reduce meat spoilage. Bacterial counts are presented in Table 1.

Dietary treatment affected tenderness (P=.0013). The diets that contained 12 g/d and 15 g/d of NaturSafe®, along with the +AB control, exhibited lower shear force values indicating the steaks were more tender than the 18 g/d NaturSafe® and -AB control (Figure 1). Tenderness is extremely influential in consumers' decisions to repurchase meat.

Sarcomere length, pH, and collagen content were measured as potential indicators of meat tenderness. Typically, a longer sarcomere length, higher pH, and less collagen are associated with greater tenderness. Dietary treatment, however, had no effect

Table 2. Instrumental color values (L*, a*, b*) of strip loins steaks from steers fed either a control diet without antibiotics, control diet with antibiotics, 12 g/d, 15 g/d, or 18 g/d NaturSafe®.

		Dietary Treatment					
Instrumental Color Values	Aging	Control No DV, No antibiotics	Control-Antibiotics	12 g/d NaturSafe®	15 g/d NaturSafe®	18 g/d NaturSafe®	P-Value
L*	13 d	43.43[c]	46.28[a]	46.15[ab]	45.09[b]	44.75[b]	0.0111
	29 d	45.54[b]	46.57[a]	45.06[b]	45.57[ab]	46.26[ab]	
a*	N/A	19.41[b]	19.50[b]	18.52[b]	18.64[b]	20.54[a]	0.0003
b*	N/A	9.29[b]	9.84[a]	9.09[b]	9.36[b]	10.11[a]	0.0005

[a-c] Means in the same row with common superscript letters are not different (P<0.05).

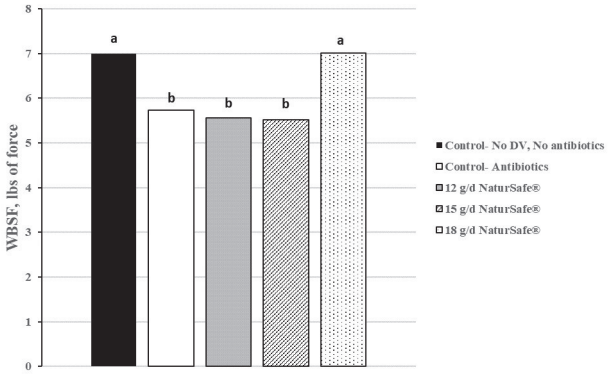

Figure 1. Warner Bratzler Shear Force of strip loins steaks fed either a control diet without antibiotics, control diet with antibiotics, 12 g/d, 15 g/d, or 18 g/d NaturSafe®.
[a,b] Different superscripts indicated differences (P<0.05).

on sarcomere length, pH, total collagen, insoluble collagen, and proximate composition (Table 1). Differences in collagen could have contributed to tenderness results or to overall eating quality for consumers if a significant difference would have been observed.

Days of aging had an effect on free Ca^{2+} concentration (P<.0001). Steaks that were aged for 29 d exhibited higher amounts of free calcium concentration than the 13 d steaks (P<.0001). However, no dietary treatment was observed for free Ca^{2+} concentration (P=.1779). Free Ca^{2+} concentration values can be found in Table 1. Calcium plays a major role in meat tenderization. Free Ca^{2+} concentration was measured since an increase in Ca^{2+} could activate enzymes causing an increase in proteolysis and leading to more tender meat. However, the lack of difference in free Ca^{2+} concentration does not explain observed differences in tenderness.

Troponin-T degradation was utilized as an indicator of proteolysis. During proteolysis, enzymes start breaking down different structures in the sarcomere and myofibril that leads to an increase in meat tenderness. Therefore, degradation of proteins, such as troponin-T often is used as an indicator of tenderness. However, there was no dietary treatment effect on troponin-T degradation (P=.3330). As anticipated, steaks aged for 29 d had higher amounts of troponin-T degradation than those aged 13 d (P<.0001).

Dietary treatment had an effect on fatty acid profile when compared on a mg/100 g tissue basis (Table 1, P=.0302). The +AB control group had significantly more alpha-linolenic acid [C18:3w3] than the 15 g/d and 18 g/d NaturSafe steaks on a mg/100 g tissue basis There were no other differences among the fatty acid profiles on both a percentage and mg/100 g tissue basis.

Lipid oxidation was determined as an indicator of oxidation or rancidity of the meat. Diet had no effect on lipid oxidation (P=.5438). The TBARS values displayed a days of aging by retail display interaction (P=.0164). Steaks aged for 29 d and subjected to 7 d of retail display had the highest TBARS values, as expected. Steaks that were aged for both 13 d and 29 d and not subjected to retail display had the lowest lipid oxidation. However, it should be noted that mean values for days of aging by retail display ranged from 1.13 to 2.60 mg malonaldehyde/kg. The values obtained would not relate to extreme off-flavors or detrimental effects on quality.

Color is the number one factor consumers consider when making their purchasing decisions. Consumers desire a bright red cherry color meat. The L* values represent darkness to lightness, a* measures greenness to redness, and b* is an indicator of blueness to yellowness. The L* values increased or became lighter over retail display and had a days of aging by retail display effect (P<.0001). Steaks that were aged for 13 d had significantly higher L* values at 6 d of retail display compared to the 29 d steaks. The L* values also had dietary treatment by days of aging effect (P=.0111). There were no differences in lightness for the control (+AB), 12 g/d, and 15 g/d of NaturSafe® among aging periods. The a* and b* values exhibited a dietary treatment effect and a days of aging by retail display effect (Table 2). Steaks from cattle fed 18 g/d, NaturSafe®, had significantly higher a* values than all other treatments (P=.0003). The a* values decreased as days of retail display increased for both aging periods, however, the 13 d aged steaks had significantly higher a* values at every day of retail display than the 29 d aged steaks (P<.0001). The b* values followed the same trend as a*, decreasing as days of retail displayed increased. The 18 g/d of NaturSafe® and control (+AB) had significantly higher b* values than all other treatments (P=.0005). A significant difference between the aging periods can be found beginning at 2 d and continuing throughout the rest of retail display with 29

d having a lower b* value than 13 d aged steaks ($P<.0001$).

Percentage of metmyoglobin and oxymyoglobin were both influenced by days of aging with oxymyoglobin being higher in the 13 d aged steaks and metmyoglobin being lower, compared to the 29 d steaks ($P<.0001$). Deoxymyoglobin was influenced by both days of aging and dietary treatment. Steaks aged for 29 d had significantly more percent deoxymyoglobin than the 13 d steaks ($P=.0024$). The 15 g/d of NaturSafe® had more deoxymyoglobin than both controls and the 12 g/d of NaturSafe® ($P=.0077$). A greater percent of oxymyoglobin is most desirable because it indicates that oxygen is bound to the heme iron molecule, creating a bright red color. Dietary treatment by days of aging and days of aging by retail display both influenced discoloration. Steaks from the 15 g/d NaturSafe®, aged for 29 d had the largest amount of discoloration compared to all other treatments ($P=.0010$). However, it should be noted that discoloration values for all steaks were quite low. Discoloration for the 29 d steaks was significantly higher at days 6 and 7 of retail display compared to the 13 d steaks ($P<.0001$).

These data suggest that feeding NaturSafe® 12 g/d or 15 g/d to cattle caused very few differences in beef characteristics compared to the control diet with antibiotics. Feeding NaturSafe® to cattle at 18 g/d caused a few more differences compared to the other two levels of NaturSafe®. Overall, feeding NaturSafe® had minimal discernible effects on meat quality.

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Impact of Diet and Quality Grade on Shelf Life of Beef Steaks

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Summary with Implications

Steers were fed a diet containing dry rolled corn, steam flaked corn, dry rolled corn with 30% dried distillers grains, or steam flaked corn with 30% dried distillers grains. Strip loins from upper 2/3 Choice and Select-grade carcasses were obtained to evaluate the effects of diet and quality grade on shelf life characteristics. Strip loins were aged for 2, 9, 16, or 23 days. Results suggest that steaks from cattle fed steam flaked corn (with or without dried distillers grains) and from cattle fed dried distillers grains (regardless of corn type) had higher levels of many unsaturated fatty acids, more discoloration, and greater lipid oxidation compared to the dry rolled corn treatments or the no dried distillers grains treatments, respectively. Feeding of dry rolled corn or diets without dried distillers grains maintained red color better during retail display. Choice-grade steaks had significantly higher levels of unsaturated fatty acids like 18:2 and total polyunsaturated fatty acids than Select-grade steaks but did not differ in color stability or oxidation. These data indicate the longest shelf life will occur when cattle are fed diets containing dry rolled corn (versus steam flaked corn) or without dried distillers grains (versus with dried distillers grains) and that both steam flaked corn and distillers grains have a negative impact on shelf life. Quality grade did not affect color stability.

Introduction

Discounted meat, caused by discoloration, costs the meat industry $1 billion annually. Currently, supplementation of dried distiller grains (DDGS) in the diet is commonly utilized to improve animal growth and performance. However, feeding DDGS to cattle has also been shown to deposit more polyunsaturated fatty acids (PUFA's) in the lean phospholipid bilayer than corn-based diets. That increases potential lipid and myoglobin oxidation which can lead to shorter shelf life and development of off/rancid flavors. This may be further influenced with the processing method of corn. Substitution of steam flaked corn (SFC) for dry rolled corn (DRC) has been found to improve certain growth traits, due to improved absorption of nutrients. A greater understanding on how these dietary treatments can impact shelf life can be valuable in deciding what cattle are fed. Consequently, this study was conducted to determine the effects of feeding SFC or DRC (with and without DDGS) and quality grade on shelf life during retail display.

Procedure

A total of 240 steers were dispersed among 24 pens (10 head/pen) and fed for 202 d on diets containing DRC, DRC+ 30% DDGS, SFC, or SFC+ 30% DDGS. A minimum of one Upper 2/3 Choice and one Select grade strip loin were selected from each pen. Pens without one of each grade were not sampled. In total, 15 Select and 21 Upper 2/3 Choice carcasses were selected from each diet. Strip loins from both sides of each carcass were halved and randomly assigned to one of four aging periods (2, 9, 16, and 23 d). After aging, loins were fabricated into longissimus steaks and trimmed of all subcutaneous fat. Steaks utilized for color and fatty acids were 1 inch thick, while beef steaks for measurement of oxidative rancidity (TBARs) were 0.75 inch thick. After fabrication, steaks used for color analysis and TBARs were overwrapped with oxygen permeable film on foam trays and placed under retail display (RD) for 7 d at 3°C. Steaks for fatty acid profile were analyzed at 2 d postmortem.

Discoloration score (percent discoloration) was measured daily, during the retail display, for 7 d. Scores were evaluated by five trained panelists with 0% being no discoloration, and 100% being complete surface discoloration. Instrumental color was measured daily with a Minolta Colorimeter set with a D65 illuminant, 2° observer (CR-400, Minolta Camera Company, Osaka, Japan). Measurements were obtained by averaging six readings from different sections of the surface on the strip steak. The CIE L*, a*, and b* values refer to lightness, redness, and yellowness, respectively.

One gram (g) of powdered Longissimus lumborum was analyzed using gas chromatography. Fatty acids were extracted, separated using a Chrompack CP-Sil 88 capillary column, and identified by retention times in comparison to known commercial standards. The percentage of fatty acids were determined by relative peak areas in the chromatograph. Those values were adjusted with the percent fat in the sample to mg/100 g tissue.

Thiobarbituric acid reactive substances were measured with 5 g of powdered beef steak at 2, 9, 16, 23 d of aging as a measure of oxidative rancidity. Results from the TBARs protocol are expressed in mg of malonaldehyde per kg of muscle tissue.

Color data were analyzed as a 2×2×2 factorial with a split plot design. Day of retail display served as a repeated measure. The processing method of corn, presence or absence of DDGS, and quality grade served as the main plot factors and aging period was the split-plot factor. Fatty acid profile was analyzed as a 2×2×2 factorial. The TBARs data were analyzed as a 2×2×2 split-split plot design. The first split plot was aging period, and the second split-plot was day of retail display. Pen was the experimental unit and data were analyzed using PROC GLIMMIX program of SAS with LSMEANS statement. Statistical significance was determined at $P<0.05$ and trends noted at $P<0.10$.

Table 1. Amount of fatty acids for strip steaks from steers fed different processed corn diets of DRC (dry rolled corn) or SFC (steam flaked corn)

Fatty Acid, mg/100g	DRC	SFC	SEM	P value
C10:0	3.74	5.59	1.05	0.314
C12:0	6.13	6.23	0.78	0.952
C13:0	2.21	1.37	0.69	0.516
C14:0	213.53	223.00	10.67	0.650
C14:1	74.56	63.95	5.65	0.274
C15:0	31.83	34.00	1.94	0.559
C15:1	65.03	62.10	4.49	0.743
C16:0	1610.54	1616.92	68.01	0.963
C16:1T	22.65	21.65	1.05	0.624
C16:1	254.00	237.12	13.49	0.508
C17:0	74.67	84.94	5.56	0.284
C17:1	84.45	86.07	4.26	0.850
C18:0	710.08	715.18	33.82	0.941
C18:1T	109.39[b]	320.85[a]	64.97	<0.0001
C18:1	2129.77	1968.75	158.61	0.600
C18:1V	245.79	196.16	136.91	0.857
C18:2T	34.81	30.08	2.27	0.203
C18:2	328.79[b]	414.82[a]	30.22	0.019
C18:3ω6	1.39	0.48	0.47	0.251
C18:3ω3	12.72[b]	15.53[a]	1.05	0.045
C20:1	30.30	33.08	2.56	0.572
C20:3	19.43	18.22	0.96	0.505
C20:4ω6	62.71	62.16	4.73	0.954
C22:1	2.32	2.30	2.11	0.995
C22:4	2.68	1.43	0.73	0.334
C22:5	15.55	16.66	1.05	0.584
Other	16.20	4.79	6.25	0.445
SFA	2652.74	2687.22	113.74	0.880
UFA	3498.91	3551.42	137.25	0.849
MUFA	3018.28	2992.04	125.85	0.918
PUFA	480.63	559.38	32.17	0.095
Trans	166.85[b]	372.59[a]	63.64	0.0001
ω6	64.10	62.64	4.72	0.878
ω3	12.72[b]	15.53[a]	1.05	0.045
Total Lipids	0.06	0.06	0.0024	0.87

[a,b] Means in the same row without common superscripts differ ($P<0.05$)

SFA- Saturated Fatty Acids

UFA- Unsaturated Fatty Acids

MUFA- Monounsaturated Fatty Acids

PUFA- Polyunsaturated Fatty Acids

Trans- Trans-unsaturated Fatty Acids

Results

Processing method of corn (DRC versus SFC) had an impact on the amount and type of fatty acids present in the meat. Fatty acids such as linoleic acid (18:2) and some trans-unsaturated fats, in general, were found in significantly higher ($P<0.05$) amounts (mg/100 g of tissue) in beef steaks from cattle fed SFC than beef steaks from DRC diet (Table 1). Linoleic acid (18:2), palmitelaidic (16:1T), and polyunsaturated fatty acids (PUFAs) were significantly higher ($P<0.05$) in beef steaks from cattle fed DDGS than the diets without DDGS (Table 2). An interaction between processing method of corn and presence or absence of DDGS was seen in a few of the fatty acids. Steaks from cattle fed DRC had significantly higher levels ($P<0.05$) of pentadecanoic acid (C15:0) compared to DRC with DDGS and SFC with DDGS had significantly higher levels ($P<0.05$) of the other, unidentified fatty acids, compared to DRC with DDGS (Table 3). The only interaction ($P<0.05$) between processing method of corn and quality grade was for elaidic acid (18:1 T) and trans-unsaturated fatty acids, with higher levels being seen in Choice-grade beef steaks from cattle fed SFC compared to all other diets. Quality grade was only significant for fatty acid profile and was not shown to be significant for any of the other measurements. An effect of marbling was also found with Choice-grade steaks having significantly higher levels of unsaturated fatty acids like 18:2 and total polyunsaturated fatty acids than Select-grade steaks but no differences in color stability or oxidation.

Discoloration and redness (a*) have profound impacts on consumer decisions to purchase beef at retail. Both color traits were influenced by length of cooler storage and day of retail display. The simulated retail display conditions in our laboratory are colder than those typically observed in retail stores. This provides the opportunity to more carefully study changes in color characteristics during retail display. No differences in any color trait were observed within the first 4 d of retail display. Effects of corn processing method and presence or absence of DDGS were apparent following 5–7 d of retail display. For all treatments, discoloration tended to increase, and redness tended to decrease during days 5–7 of retail display following 2 and 9 d of aging (Figures 1–4). Differences in discoloration and redness between DRC and SFC were significant following 16 and 23 d of storage, with steaks from cattle fed SFC exhibiting significantly more discoloration (Figure 1) and reduced redness (Figure 3) than steaks from cattle fed DRC after 6 or 7 d under simulated retail display conditions. Steaks from cattle fed diets containing DDGS, compared to diets without DDGS, showed the same results, in that the presence of DDGS in the diet resulted in significant increases ($P<0.05$) in discoloration (Figure

Table 2. Amount of fatty acids for strip steaks from steers fed with or without DDGS (dried distiller grains)

Fatty Acid, mg/100g	NO DDGS	DDGS	SEM	P value
C10:0	4.91	4.42	0.91	0.79
C12:0	7.14	5.22	0.96	0.23
C13:0	2.21	1.37	0.69	0.52
C14:0	232.84	203.69	13.31	0.17
C14:1	76.17	62.35	6.20	0.16
C15:0	35.78	30.05	2.47	0.13
C15:1	63.40	63.73	4.41	0.97
C16:0	1618.65	1608.81	68.05	0.94
C16:1T	19.91[b]	24.39[a]	1.64	0.035
C16:1	260.30	230.82	15.19	0.25
C17:0	83.34	76.27	5.12	0.46
C17:1	89.74	80.78	4.96	0.30
C18:0	649.43	775.83	49.73	0.072
C18:1T	237.65	192.60	25.76	0.32
C18:1	2088.46	2010.06	153.32	0.80
C18:1V	99.05	342.91	153.28	0.38
C18:2T	31.14	33.75	1.96	0.48
C18:2	316.24[b]	427.37[a]	36.41	0.003
C18:3ω6	0.47	1.40	0.47	0.24
C18:3ω3	14.00	14.25	1.05	0.85
C20:1	28.36	35.03	3.10	0.18
C20:3	17.51	20.15	1.17	0.15
C20:4ω6	60.41	64.45	4.87	0.67
C22:1	0.00	4.62	2.50	0.28
C22:4	0.95	3.15	0.90	0.095
C22:5	16.10	16.10	1.00	1.00
Other	3.64	17.35	7.39	0.24
SFA	2634.31	2705.65	115.16	0.76
UFA	3422.41	3627.92	148.75	0.46
MUFA	2963.02	3047.29	127.96	0.74
PUFA	459.39[b]	580.63[a]	41.75	0.013
Trans	288.70	250.74	25.34	0.41
ω6	60.88	65.85	4.92	0.60
ω3	14.00	14.25	0.67	0.85
Total Lipids	0.061	0.064	0.0026	0.55

[a,b] Means in the same row without common superscripts differ ($P<0.05$)

SFA- Saturated Fatty Acids

UFA- Unsaturated Fatty Acids

MUFA- Monounsaturated Fatty Acids

PUFA- Polyunsaturated Fatty Acids

Trans- Trans-unsaturated Fatty Acids

2) and reductions in redness (Figure 4) after 6–7 day of retail display following extended storage (16 and 23 d).

Detrimental effects of SFC (versus DRC) and DDGS (versus diets without DDGS) were also observed with oxidation (TBARs) following 7 d of retail display, regardless of storage time (Figures 5 and 6). Steaks did not differ in oxidation level at the beginning of the retail period. Not surprisingly, exposure to oxygen, as occurs during retail display, is required for oxidation to occur. Lipid oxidation is associated with rancidity and discoloration, so feeding SFC or DDGS may have detrimental effects to retail value of beef steaks compared to DRC or No DDGS. This suggests that the DRC diet (without DDGS) is better able to maintain visual desired color than SFC or DDGS and thus would take longer to be discounted.

Results suggest that beef steaks from cattle fed SFC or DDGS have a reduced color and lipid stability compared to DRC or No DDGS, and accordingly lead to a reduced shelf life. Furthermore, fatty acid profile showed higher levels of key fatty acid(s) like linoleic acid and PUFAs in SFC+ DDGS compared to DRC and Choice steaks compared to Select steaks. Thus, diet composition can impact beef shelf life.

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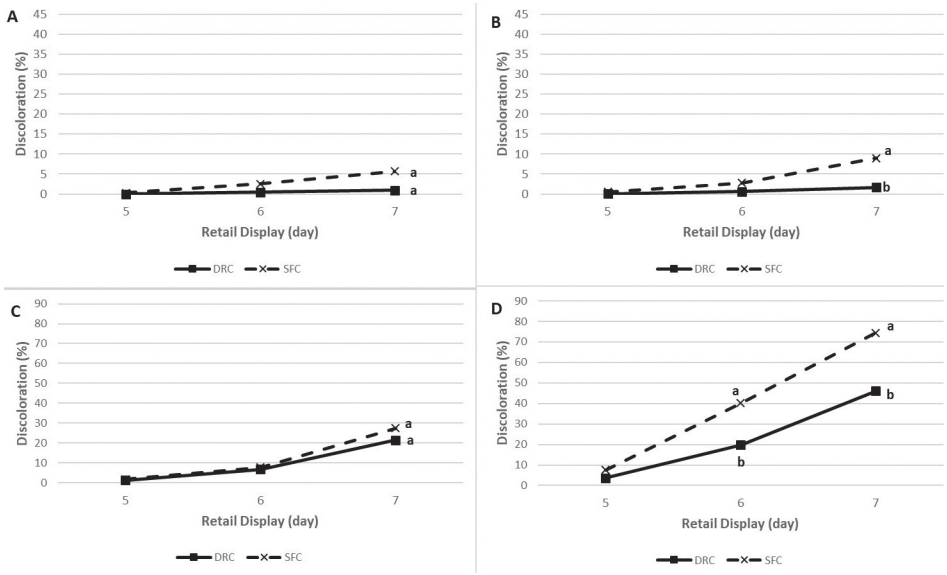

Figure 1. Discoloration (%) of strip loin steaks (*L. lumborum*) from steers fed either dry rolled corn (DRC), or steam flaked corn (SFC) with 2, 9, 16, and 23 d of aging at 7 d retail display.
[a,b] Means in the same row without common superscripts differ ($P<0.05$)
A: Discoloration 2 days aged loins (at 45% y-axis)
B: Discoloration 9 days aged loins (at 45% y-axis)
C: Discoloration 16 days aged loins (at 90% y-axis)
D: Discoloration 23 days aged loins (at 90% y-axis)

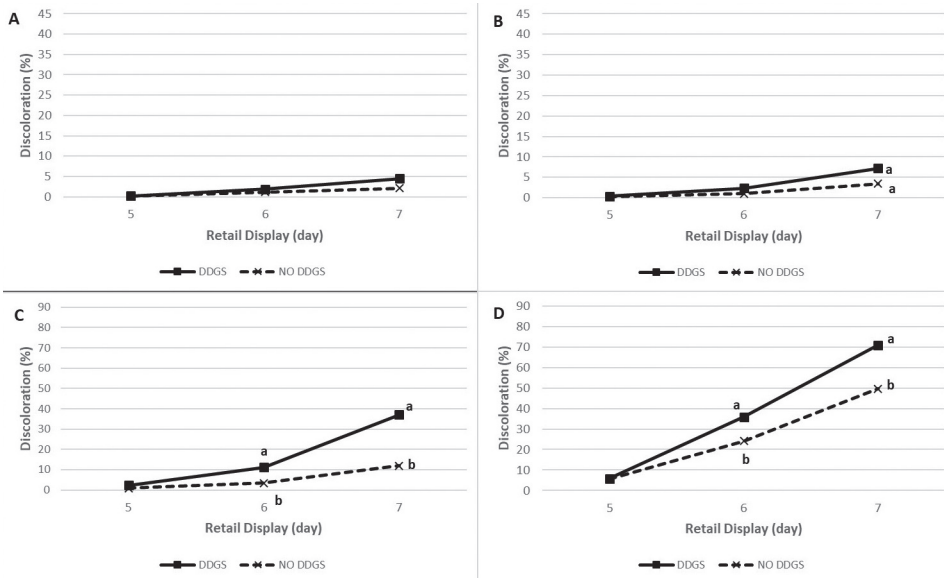

Figure 2. Discoloration (%) of strip loin steaks (*L. lumborum*) from steers fed either with Dried Distiller Grains (DDGS) or without DDGS (No DDGS) with 2, 9, 16, and 23 d of aging at 7 d retail display.
[a,b] Means in the same row without common superscripts differ ($P<0.05$)
A: Discoloration 2 days aged loins (at 45% y-axis)
B: Discoloration 9 days aged loins (at 45% y-axis)
C: Discoloration 16 days aged loins (at 90% y-axis)
D: Discoloration 23 days aged loins (at 90% y-axis)

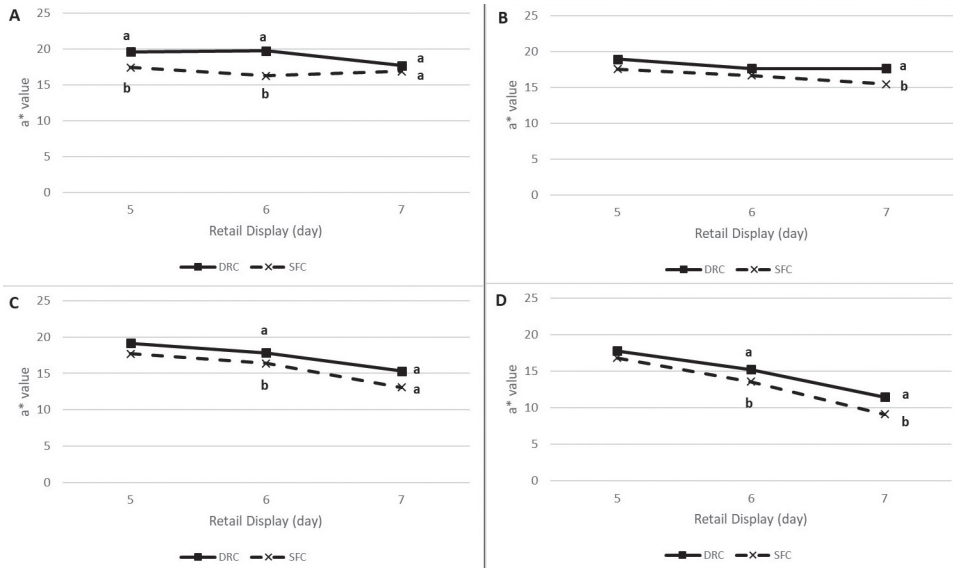

Figure 3. Redness (a*) of strip loin steaks (*L. lumborum*) from steers fed either Dry Rolled Corn (DRC), or Steam Flaked Corn (SFC) with 2, 9, 16, and 23 d of aging at 7 d retail display.
[a,b] Means in the same row without common superscripts differ ($P<0.05$)
A: a* 2 days aged loins
B: a* 9 days aged loins
C: a* 16 days aged loins
D: a* 23 days aged loins

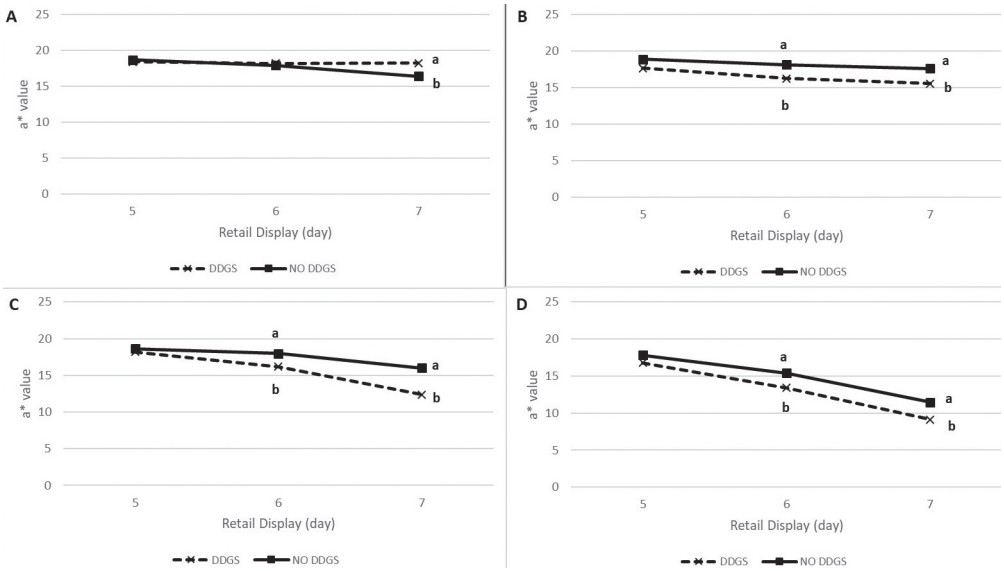

Figure 4. Redness (a*) of strip loin steaks (*L. lumborum*) from steers fed either with Dried Distiller Grains (DDGS) or without DDGS (No DDGS) with 2, 9, 16, and 23 d of aging at 7 d retail display.
[a,b] Means in the same row without common superscripts differ ($P<0.05$)
A: a* 2 days aged loins
B: a* 9 days aged loins
C: a* 16 days aged loins
D: a* 23 days aged loins

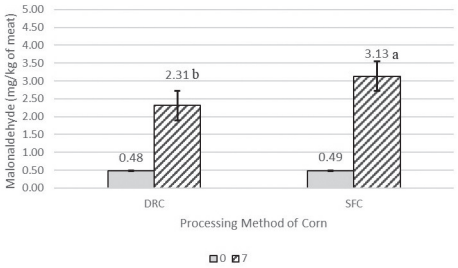

Figure 5. Lipid oxidation values (TBARs; mg malonaldehyde/ kg of meat) of strip steaks (*L. lumborum*) from steers fed either Dry Rolled Corn (DRC or Steam Flaked Corn (SFC) at 0 and 7 d retail display.
[a,b] Means within day without common superscripts differ ($P<0.05$)

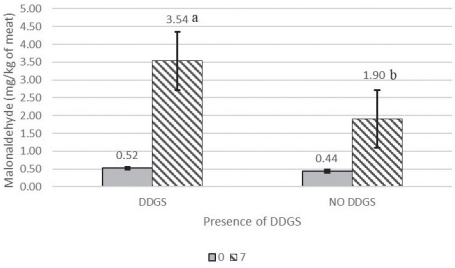

Figure 6. Lipid oxidation values (TBARs; mg malonaldehyde/ kg of meat) of strip steaks (*L. lumborum*) from steers fed either with Dried Distiller Grains (DDGS) or without DDGS (No DDGS) at 0 and 7 d retail display.
[a,b] Means within day without common superscripts differ ($P<0.05$)

Table 3. Amount of fatty acids for strip steaks from steers fed different processed corn diets of DRC (dry rolled corn) or SFC (steam flaked corn) and with or without DDGS (dried distiller grains)

Fatty Acid, mg/100g	DRC	DRC+D-DGS	SFC	SFC+D-DGS	SEM	P value
C15:0	39.97[a]	23.70[b]	31.59[ab]	36.41[ab]	15.59	0.0077
C16:1T	23.12[ab]	22.18[ab]	16.70[b]	26.60[a]	8.91	0.012
C17:0	89.70[ab]	59.65[b]	76.99[ab]	92.89[a]	32.80	0.021
C17:1	104.07[a]	64.83[b]	75.40[ab]	96.73[a]	40.36	0.0014
Total Lipids	0.064	0.059	0.057	0.068	0.012	0.097

[a,b] Means in the same row without common superscripts differ ($P<0.05$)

Table 4. Amount of fatty acids for either choice or select quality grade strip steaks

Fatty Acid, mg/100g	Choice	Select	SEM	P value
C10:0	6.55[a]	2.78[b]	1.41	0.0464
C12:0	8.35[a]	4.01[b]	1.48	0.01
C13:0	0.00[b]	3.58[a]	1.95	0.0094
C14:0	285.47[a]	151.05[b]	40.15	<0.0001
C14:1	86.39[a]	41.29[b]	24.96	<0.0001
C15:0	42.37[a]	23.46[b]	5.76	<0.0001
C15:1	74.57[a]	52.56[b]	7.74	0.019
C16:0	2087.33[a]	1140.13[b]	281.76	<0.0001
C16:1T	27.05[a]	17.25[b]	3.00	<0.0001
C16:1	312.31[a]	178.81[b]	58.18	<0.0001
C17:0	102.50[a]	57.11[b]	13.92	<0.0001
C17:1	108.80[a]	61.72[b]	14.24	<0.0001
C18:0	882.84[a]	542.43[b]	103.92	<0.0001
C18:1T	287.53[a]	142.72[b]	47.35	0.003
C18:1	2524.68[a]	1573.84[b]	313.59	0.0041
C18:1V	370.15	71.81	161.11	0.2829
C18:2T	41.25[a]	23.64[b]	5.40	<0.0001
C18:2	425.80[a]	317.81[b]	35.61	0.0041
C18:3ω6	0.23	1.64	1.76	0.081
C18:3ω3	17.76[a]	10.49[b]	2.20	<0.0001
C20:1	42.00[a]	21.38[b]	6.43	0.0002
C20:3	20.33	17.33	1.24	0.1053
C20:4ω6	63.15	61.71	8.61	0.8799
C22:1	2.32	2.30	2.11	0.9951
C22:4	1.57	2.54	1.72	0.4526
C22:5	14.44	17.77	2.53	0.1056
Other	16.08	4.91	6.58	0.2416
SFA	3415.41[a]	1924.54[b]	445.04	<0.0001
UFA	4426.09[a]	2624.24[b]	537.74	<0.0001
MUFA	3841.56[a]	2168.75[b]	498.97	<0.0001
PUFA	584.53[a]	455.49[b]	43.65	0.0086
Trans	355.83[a]	183.61[b]	54.71	0.0008
ω6	63.39	63.35	4.70	0.9967
ω3	17.76[a]	10.49[b]	2.20	<0.0001
Total Lipids	0.079[a]	0.046[b]	0.0098	<0.0001

[a,b] Means in the same row without common superscripts differ ($P<0.05$)

Statistics Used in the Nebraska Beef Cattle Report and Their Purpose

The purpose of beef cattle and beef product research at UNL is to provide reference information that represents the various populations (cows, calves, heifers, feeders, carcasses, retail products, etc) of beef production. Obviously, the researcher cannot apply treatments to every member of a population; therefore he/she must sample the population. The use of statistics allows the researcher and readers of the Nebraska Beef Cattle Report the opportunity to evaluate separation of random (chance) occurrences and real biological effects of a treatment. Following is a brief description of the major statistics used in the beef report. For a more detailed description of the expectations of authors and parameters used in animal science see Journal of Animal Science Style and Form at: http://jas.fass.org/misc/ifora.shtml.

—**Mean:** Data for individual experimental units (cows, steers, steaks) exposed to the same treatment are generally averaged and reported in the text, tables and figures. The statistical term representing the average of a group of data points is mean.

—**Variability:** The inconsistency among the individual experimental units used to calculate a mean for the item measured is the variance. For example, if the ADG for all the steers used to calculate the mean for a treatment is 3.5 lb then the variance is zero. But, this situation never happens! However, if ADG for individual steers used to calculate the mean for a treatment range from 1.0 lb to 5.0 lb, then the variance is large. The variance may be reported as standard deviation (square root of the variance) or as standard error of the mean. The standard error is the standard deviation of the mean as if we had done repeated samplings of data to calculate multiple means for a given treatment. In most cases treatment means and their measure of variability will be expressed as follows: 3.5 ± 0.15. This would be a mean of 3.5 followed by the standard error of the mean of 0.15. A helpful step combining both the mean and the variability from an experiment to conclude whether the treatment results in a real biological effect is to calculate a 95% confidence interval. This interval would be twice the standard error added to and subtracted from the mean. In the example above, this interval is 3.2–3.8 lb. If in an experiment, these intervals calculated for treatments of interest overlap, the experiment does not provide satisfactory evidence to conclude that treatments effects are different.

—***P* Value:** Probability (*P* Value) refers to the likelihood the observed differences among treatment means are due to chance. For example, if the author reports $P \leq 0.05$ as the significance level for a test of the differences between treatments as they affect ADG, the reader may conclude there is less than a 5% chance the differences observed between the means are a random occurrence and the treatments do not affect ADG. Hence we conclude that, because this probability of chance occurrence is small, there must be difference between the treatments in their effect on ADG. It is generally accepted among researchers when *P* values are less than or equal to 0.05, observed differences are deemed due to important treatment effects. Authors occasionally conclude that an effect is significant, hence real, if *P* values are between 0.05 and 0.10. Further, some authors may include a statement indicating there was a tendency or trend in the data. Authors often use these statements when *P* values are between 0.10 and 0.15, because they are not confident the differences among treatment means are real treatment effects. With *P* values of 0.10 and 0.15 the chance random sampling caused the observed differences is 1 in 10 and 1 in 6.7, respectively.

—**Linear & Quadratic Contrasts:** Some articles contain linear (L) and quadratic (Q) responses to treatments. These parameters are used when the research involves increasing amounts of a factor as treatments. Examples are increasing amounts of a ration ingredient (corn, by-product, or feed additive) or increasing amounts of a nutrient (protein, calcium, or vitamin E). The L and Q contrasts provide information regarding the shape of the response. Linear indicates a straight line response and quadratic indicates a curved response. P-values for these contrasts have the same interpretation as described above.

—**Correlation (r):** Correlation indicates amount of linear relationship of two measurements. The correlation coefficient can range from -1 to 1. Values near zero indicate a weak relationship, values near 1 indicate a strong positive relationship, and a value of -1 indicates a strong negative relationship.